MANUAL for DENTAL TECHNICIANS

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INTRODUCTION

This text has been written for the purpose of gathering under one cover, information for the student dental technician on the issues involved; the basic techniques followed; and the materials used in the dental laboratory. No attempt has been made to cover every phase of the work, or to go into detail on complicated procedures, but it has been the desire of the author to give the student a basic knowledge of procedure, so that he will have a foundation from which he may develop according to his natural ability, resources, and ambition.

The procedures followed in the dental laboratory relating to dentistry can be roughly divided into two classes, namely Repairative and Restorative. Repairative procedures are those relating to Operative dentistry in which the technician aids in the construction of fillings or crowns to restore lost tooth structure. However, the bulk of the work that is done by the dental technician will fall under the Restorative classification, which is known as Prosthetic dentistry.

Prosthetic dentistry may be defined as that branch of dental science which deals with the various methods of replacing the lost organs of the mouth, in whole or in part, and the artistic and mechanical processes involved, together with a description of the physical properties and peculiarities of the materials employed.

Since the text includes many aspects of the work, it has been found necessary to divide the book into three parts and an appendix, as follows:

PART I	DENTAL MATERIALS
PART II	ANATOMICAL STRUCTURES
PART III	LABORATORY TECHNIQUE
APPENDIX	RECORDS, CHARTS, SYSTEMS OF WEIGHTS AND MEASURES, TEMPERATURE SCALES

PART I

DENTAL MATERIALS

DENTAL MATERIALS

As dental technicians our work will consist almost entirely of the construction of bridges, dentures, and appliances which replace teeth that have been lost from one cause or another. It goes without saying that we must have a thorough knowledge of the technical procedures involved in the construction of these appliances, but we should also know something of the properties and peculiarities of the materials with which we work.

In practically all dental materials certain desirable properties have been built into their products by the manufacturers, and certain undesirable properties have been eliminated. We should know what properties are desirable in various materials, to what degree these properties are present in the materials we are using, and we should know how to work the materials in the way that will give us maximum results. If we know something of the composition of our materials, we can more readily understand why certain things can be done, and why certain things must be avoided.

With these things in mind, the lectures on dental materials have been prepared, and it is hoped that they will enable you to avoid blunders which might easily be made if you had no knowledge of the subject.

METALLURGY

Metallurgy may be defined as the science of the extraction of metals from their ores, and of their preparation for use.

Physical Properties of Metals - There are about 92 chemical elements known at the present time, and most of them can be classified as either metallic or non-metallic. The non-metals are represented by such elements as oxygen, chlorine, sulphur and carbon, and are characterized by several properties which are distinctly different from those of the metals. Most of the non-metals are non-conductors or poor conductors of heat and electricity. They are transparent or translucent in the crystalline form and have a low specific gravity. They are non-malleable and non-ductile, and several of them are gases at ordinary temperatures.

On the other hand, metals are opaque, possess what we call metallic luster, and are good conductors of electricity. Several of the metals are malleable and ductile, and many possess a high specific gravity. All of the metals are solid at ordinary temperatures with the exception of mercury.

The properties listed are thought to be of more importance to us than some of the others, and it is with these that we shall be chiefly concerned. Each one will be taken up separately and described so that you will know just what is meant by each of them.

1. Hardness.
2. Malleability.
3. Ductility.
4. Elasticity
5. Tenacity.
6. Conductivity.
7. Expansion.
8. Fusibility and Volatility.
9. Weldability.
10. Density or Specific Gravity.
11. Color and Luster.
12. Fatigue.

1. <u>HARDNESS</u> - This may be defined as that property of a material which causes it to resist permanent deformation by an external force. A hard metal may, or may not be easily broken, but it is resistant to scratching and to bending, and to any deformation caused by pressure or impact.

Hardness may be very roughly estimated by cutting the metal with a good steel knife. The various metals differ greatly in their hardness, lead being so soft that it can be scratched with the fingernail, while metals such as nickel and iron can be scratched only by very hard materials.

2. <u>MALLEABILITY</u>- This is the property of a metal that permits it to be permanently extended in all directions without fracture by impact or pressure such as hammering or rolling. In other words, it is the ability to be beaten or rolled into thin sheets without breaking. All so-called tough metals are malleable to some extent while brittle metals are non-malleable. Materials that are malleable can be worked into shape, whereas brittle metals must be cast into molds to obtain the desired shape.

Malleability and brittleness are directly dependent on the hardness and crystalline condition of the metals. Bismuth, arsenic, and antimony are examples of non-malleable metals, and are so brittle that they fly to pieces when struck with a hammer. They can also be powdered in a mortar.

The malleability of metals is impaired when they are subjected to long continued hammering or rolling. This property can be restored by correct heat treatment (annealing). In the case of gold or noble metal alloys the metal is heated to a uniform red heat and plunged into cold water. Steel or iron alloys are heated to redness and allowed to cool slowly.

3. <u>DUCTILITY</u> - This is the property of a metal that permits it to be drawn into a wire.

Practically all metals that are malleable are also ductile, but they do not possess the two properties in the same order. Since strength as well as malleability is required of a metal in pulling it through a die, a metal which is very malleable is not necessarily also very ductile, because it might break due to insufficient strength to stand the pulling process. Gold and silver are so ductile that they can be drawn into wires so fine that they are practically invisible to the unaided eye.

4. <u>ELASTICITY</u> - This is the property a metal possesses of resuming its original form after removing a force which has produced a change in that form. This property also varies greatly in different metals. Good

steel possesses it in a high degree, while lead scarcely shows a trace of it. Annealing diminishes elasticity, but proper tempering restores it.

Elasticity in a metal can often be developed by combining it with another metal and making an alloy. An alloy of copper and zinc in the form of brass is very elastic, although neither metal is in itself elastic. Another example, and one with which we are directly concerned, is the case of gold and platinum. Both are soft metals, but when combined in certain proportions, form a hard, elastic alloy which we use in making clasps for partial dentures. Platinum and iridium are combined, the resulting alloy being used in making nerve canal instruments and hypodermic needles. The Limit of Elasticity is the point at which a metal is incapable of regaining its original form.

5. TENACITY - This is the property of a metal that enables it to resist rupture when exposed to a tensile or stretching force. The greatest tensile force, or stretching force, that a metal specimen can endure without being ruptured is known as its Tensile Strength. The relative tenacity of metals may be ascertained by preparing wires of exactly equal diameters, and comparing the number of pounds weight each will sustain before rupture occurs.

6. CONDUCTIVITY - This is the property of conducting heat and electricity. Most metals are good conductors of heat and electricity, although there is a great variation in this property among the various metals. The metals that are the best conductors of heat are also the best conductors of electricity, and vice versa. In dentistry the electrical conductivity of metals is not as important as some of their other properties, yet the fact that they are conductors of electricity must be considered. Since electric currents are sometimes generated during the corrosion of metals and alloys, electric currents are often present in the mouth. This property is of more importance from an operative standpoint than from a prosthetic one, because most metals used in filling teeth are good conductors, and temperature changes produced by hot food and drink would be transmitted to the sensitive tissues of the tooth, unless protected by a non-conducting material such as cement.

7. EXPANSION - Most materials expand when heated and contract when cooled. The Coefficient of Thermal Expansion is the increase per unit of length that occurs for a change in temperature of one degree. The expansion of a material may vary greatly at different temperatures, and different metals vary widely in this property. The thermal expansion of materials used in dentistry must be considered if the best results are to be obtained. The expansion of porcelain and platinum is practically identical, and for this reason platinum is invaluable in the construction of porcelain jacket crowns. A platinum cap is burnished over the model of the prepared tooth, and the porcelain crown is built upon it. During the baking process where very high temperatures are employed, a cap material with a widely different expansion than that of the porcelain would cause the crown to fracture on cooling.

8. FUSIBILITY AND VOLATILITY - By fusibility we mean the ability to pass from a solid to a fluid state. By volatility we mean the ability to volatilize or become a vapor. All metals may be fused, or melted, if heated sufficiently, but the temperature at which they fuse differs greatly for the different metals.

As an illustration of the extreme variation in the fusibility of the various metals, take mercury, gold, platinum. Mercury is a liquid at ordinary temperatures and does not freeze, or become solid until a temperature of -38 degrees Centigrade is reached. Gold and platinum, of course, are solids at ordinary temperatures and do not pass to the liquid state until very high temperatures are reached. The melting point of gold is 1063 degrees Centigrade, and that of platinum is still higher, as platinum will not melt until heated to 1755 degrees Centigrade.

9. WELDABILITY - Metals which possess the property of adhering together when subjected to an external force such as pressing or hammering without the aid of solder are said to be weldable. Some metals on cooling from the molten state, pass through a plastic stage before becoming perfectly solid, and are easily welded while in this condition. An example of this would be iron at white heat. In a few cases welding may be accomplished in the cold state when two clean surfaces of the metal are brought into close contact and hammered or pressed together. However, in the latter case the metals must be very pure, and the surfaces absolutely clean.

The property of weldability is most marked in platinum, gold, and iron, although some of the other metals are weldable in greater or lesser degree.

10. SPECIFIC GRAVITY - By this we mean the weight of a certain bulk of material as compared with the weight of exactly the same bulk of water. It is important that both the water and material be weighed at the same temperature, because increase of temperature causes expansion of a metal. The specific gravity of water is 1.00 and this is used as a standard. If a given bulk of a material weighs exactly twice as much as the same bulk of water, the specific gravity of the material is 2.00, If it weighs only half as much as the water its specific gravity is 0.50.

11. COLOR AND LUSTER - The luster of metals is due to their power of reflecting light. Metals are the most opaque materials known. In color, most of the metals range from the pure white of silver, tin, and cadmium to the bluish-black of lead. Bismuth has a very light pinkish tint, while copper is red and gold is yellow.

The colors of metals can be appreciably changed by alloying. Gold is whitened by the addition of silver and reddened by copper. In certain

proportions gold and silver will form an alloy with a greenish tint. Copper becomes a golden yellow when alloyed with aluminum or zinc. Antimony and copper will produce a violet colored alloy.

12. FATIGUE OF METALS - This can be defined as the gradual or progressive breaking of a metal specimen after subjecting it to repeated stresses, anyone of which is not great enough to cause fracture. An example of this would be a wire that is continually bent back and forth until it finally breaks.

It has long been known that metal specimens will sometimes break after repeated stresses, even though the stress is much less than the elastic limit of the metal. The mechanism of this failure is not entirely understood. However, it seems that a very minute crack starts and increases very slightly with each alternating stress until it has so weakened the piece that the stress is able to rupture the remainder. The direct causes of fatigue are not known, but it has been found that coarsely crystalline or dirty specimens have a low resistance to fatigue, while other specimens of the same material that are clean and have fine grain are much more resistant to fatigue.

RELATIVE HARDNESS, MALLEABILITY AND DUCTILITY OF SOME OF THE COMMON METALS

Hardness	Malleability	Ductility
VERY HARD	VERY MALLEABLE	VERY DUCTILE
Chromium	Gold	Gold
Iridium	Silver	Silver
Manganese	Copper	Platinum
	Aluminum	Copper
MEDIUM HARD	Tin	Aluminum
	Platinum	Nickel
Cobalt	Lead	Cobalt
Nickel		
Iron	MEDIUM MALLEABLE	MEDIUM DUCTILE
Copper		
Platinum	Zinc	Palladium
Silver	Iron	Cadmium
Tantalum	Nickel	Zinc
Magnesium	Cobalt	Tin
	Molybdenum	Lead
SOFT	NON-MALLEABLE	NON-DUCTILE
Gold	Chromium	Silicon
Aluminum	Manganese	Manganese
Cadmium	Antimony	Berylium
Tin	Bismuth	Antimony
Lead		

Gold and silver possess the property of malleability to a greater extent than any of the other metals. Gold is so malleable that one grain of it can be rolled and beaten into a leaf that will cover six square feet, the leaf having a thickness of but 0.0000033 inches. It would require 300,000 such sheets laid upon one another to make a compact pile one inch in thickness.

The degree of malleability is greatly influenced by the presence of impurities in the metal. For example, 1/2000 part of lead would make gold quite brittle, whereas normally it is the most malleable of all metals. This point is important in swaging gold against a die. During the swaging process the gold must be frequently annealed to prevent cracking, but before annealing, the gold should be boiled in acid to prevent particles of lead or other material in the die from becoming incorporated in the gold and making it brittle.

The operation of making wire consists of forcibly drawing the metal through a series of holes, which gradually decrease in size, in a hard-steel draw-plate. In making the extremely fine gold wire referred previously to under ductility, a trick was employed. This consisted of covering the gold wire with silver, which is also remarkably ductile, thus making a composite wire of greater thickness. After drawing this down to the greatest possible degree, the silver was dissolved off by nitric acid, leaving a gold wire of only 0.0002 of an inch in diameter. By this process a single grain of gold was drawn into a wire 550 feet in length.

The relative tenacity of some of the more common metals is indicated in the order given in the following table:

1. Steel.
2. Nickel.
3. Iron (wrought)
4. Platinum.
5. Iron (cast).
6. Silver.
7. Copper.
8. Gold.
9. Palladium.
10. Aluminum.
11. Zinc
12. Cadmium.
13. Tin.
14. Bismuth.
15. Antimony.
16. Lead.

SPECIFIC GRAVITY OF A FEW OF THE MORE COMMON METALS AT 20 DEGREES CENTIGRADE

Lithium	0.534	Tin	7.30	Lead	11.34
Calcium	1.54	Iron	7.85	Palladium	11.90
Magnesium	1.70	Nickel	8.60	Mercury	13.59
Aluminum	2.70	Cadmium	8.65	Tungsten	18.70
Antimony	6.68	Copper	8.90	Gold	19.32
Chromium	6.92	Bismuth	9.78	Platinum	21.37
Zinc	7.19	Molybdenum	10.20	Iridium	22.42
Manganese	7.42	Silver	10.50	Osmium	22.48

RELATIVE THERMAL EXPANSION, CONDUCTIVITY AND FUSIBILITY OF SOME OF THE COMMON METALS.

Thermal Expansion	Conductivity	Fusibility
VERY GREAT	VERY GREAT	BELOW RED HEAT
Mercury	Silver	Mercury
Tin	Copper	Tin
Cadmium	Chromium	Lead
Aluminum	Aluminum	Cadmium
Lead	Magnesium	Zinc
Silver		
MEDIUM	MEDIUM	AT RED HEAT
Nickel	Zinc	Aluminum
Iron	Palladium	Antimony
Copper	Cadmium	Silver
Gold	Platinum	Gold
	Iron	Copper
VERY LOW	LOW	AT WHITE HEAT
Platinum	Tantalum	Nickel
Tantalum	Beryllium	Iron
Iridium	Lead	Palladium
Molybdenum	Manganese	Platinum
Osmium	Antimony	Molybdenum
Tungsten	Silicon	Tantalum

TEMPERATURE SCALES

Two temperature scales are in general use in the United States. The centigrade scale is used almost exclusively in scientific work, but in the Industrial field the Fahrenheit scale is usually employed. Data using both scales are reported in dental investigations, and it is often necessary to change Centigrade to Fahrenheit and vice versa in order to read the dental literature intelligibly.

The size of the unit degree in each scale is arbitrarily defined by the freezing and boiling point of water under standard conditions. In centigrade these two temperatures are chosen as 0. and 100 degrees respectively, and in Fahrenheit scale they are 32 and 212 degrees.

The formula for changing Centigrade to Fahrenheit:

$$(C \times 9/5) + 32 = F.$$

$$(F - 32) \times 5/9 = C.$$

In heating metals the color changes as the temperature is increased. The first color noticed is a very dull red, and this changes as the metal becomes hotter to various shades of red and orange, until a dazzling white is produced. These colors are called radiation colors, and the temperature of the hot body can be fairly well estimated from the color. Some of the colors and their corresponding Centigrade temperatures are given in the following table:

Dull red, barely perceptible	500 - 600 C.
Dark red	600 - 750 C.
Cherry red	750 - 850 C.
Bright red	850 - 1000 C.
Yellowish-red or orange	1000 - 1100 C.
White	1100 - 1300 C.
Dazzling white	above 1350 C.

The colors appear slightly different to different persons, and also vary under different conditions of light. All hot objects appear brighter in a darkened room, and appear more dull in a well lighted room. For these reasons temperature determination by color is only approximate, and must not be relied on if any degree of accuracy is required.

Metals are divided into two distinct groups which we call the precious metals or noble metals, and the base metals.

THE NOBLE METALS OR PRECIOUS METALS are those which have such a slight affinity for oxygen that they do not tarnish or oxidize at ordinary temperatures or on heating, and any slight compounds formed with oxygen are reduced by heat alone at a temperature not exceeding redness.

There are only a few noble metals, and they are as follows:

1. Gold	4. Palladium	7. Osmium
2. Silver	5. Rhodium	8. Iridium
3. Platinum	6. Ruthenium	9. Mercury

THE BASE METALS are those which have a high affinity for oxygen and tarnish or oxidize at ordinary temperatures or on heating, and their compounds with oxygen are not reduced by heat alone. All metals not listed above as precious metals are base metals.

Most of the metals used in dentistry are alloys, and if we know the properties of the metals entering into their formation, we will be better able to understand just how the alloy is affected by their presence. In other words, if we have an alloy composed of gold, silver, and copper, we want you to know why the silver and copper were added, and in what ways they modify the properties of the gold.

An ALLOY is a mixture of two or more metals.

An AMALGAM is a mixture of two or more metals one of which must be mercury.

GOLD

Gold is perhaps the first metal noticed by man. Occurring as it sometimes does as bright yellow flakes in river gravel, it undoubtedly attracted early attention. Because of its easy workability and striking appearance, it was made into ornaments, and because of its rarity it was valued as a precious metal.

Gold is found in nature chiefly in the metallic state, or as native gold, but is sometimes found in combination with tellurium, lead, and silver. Native gold occurs in small grains or crystals and occasionally in larger pieces or masses which are called nuggets. The largest nugget or single piece of gold ever found was taken out at Ballarat, Victoria, Australia. It weighed 2166 ounces and was valued at $41,882. South Africa leads the world in gold production, with the United States, Canada, and Australia following in order. Gold is recovered and purified by various processes, but we shall not go into these as we are chiefly concerned with the properties of gold rather than the methods of obtaining it.

Gold is a metal with a beautiful yellow color. It is one of our softer metals, being somewhat harder than lead but softer than silver. It is also the most malleable and most ductile of any known metal. The tensile strength of gold is rather low, being about 20,000 pounds per square inch in the cast form, but nearly 40,000 pounds per square inch in the form of hard drawn wire. Pure gold is not affected by most solutions, but is soluble in cyannic acid and aqua regia.

It is probably the most noble of the noble metals, and is entirely unaffected by hydrogen sulphide and any of the other substances which may be present in the mouth.

Pure gold melts at 1063 degrees Centigrade, and volatilizes or becomes vaporous at the temperature of the oxy-hydrogen flame. Its coefficient of expansion is less than that of silver, but greater than that of platinum. Gold is extremely malleable, and because of this and the fact that it will not oxidize in the air, it can be welded cold. For use by the dental profession it is made in a variety of forms.

Pure gold is too soft and weak for most purposes, and must be alloyed with other metals to increase its strength, elasticity, and hardness. It alloys with most of the known metals. It alloys with silver, copper, and platinum being of most importance to the dentist. The amount of gold in a gold alloy is expressed as <u>fineness</u>, <u>carat</u>, or <u>per cent</u>.

<u>FINENESS</u> is the number of parts of gold per 1000 parts of alloy.

<u>CARAT</u> is the number of parts of gold per 24 parts of alloy.

<u>PER CENT</u> is the number of parts of gold per 100 parts of alloy. Pure gold may therefore be said to be 1000 fine, 24 carat, or 100 per cent gold. A gold alloy composed of 10 parts of silver and 10 parts of gold would be 500 fine, 12 carat, or 50 per cent gold content.

<u>ALLOYS OF GOLD</u> - As gold will alloy with most of the known metals there are any number of gold alloys, but our study will be confined to only those which are of importance to us in dentistry.

<u>Gold-Copper Alloys</u> - Gold and copper mix in all proportions when in the molten state. Copper imparts a reddish tinge to the gold, and makes it distinctly harder and stronger. However, it reduces the malleability and ductility, and lowers the melting point of gold. The conductivity of gold-copper alloys is less than that of either metal. Most gold coins are gold-copper alloys, those of the United States being 900 fine or 21.6 carat.

<u>Gold-Silver Alloys</u> - Gold and silver also mix readily in all proportions when melted together. Generally speaking, silver lightens the color of gold. Those alloys with only a small percentage of silver are yellow but a shade lighter than pure gold. Those containing more silver have a greenish hue, but in cases where the silver content runs as high as 50 per cent, the alloy is pale yellow or very nearly white.

Silver does not have a marked effect on the melting point of gold. It lowers it some, to be sure, but as the melting points of the two pure metals are only a little over 100 degrees (Centigrade) apart, and the melting point of the alloy lies between the two, there is no great change in this respect. Silver increases the hardness of the gold without destroying the malleability or ductility to any extent. These al-

loys are not as hard as the gold-copper alloys, but they are much more malleable and ductile. The conductivity is reduced as it is considerably less than that of either of the pure metals. Silver and copper together are often alloyed with gold, the silver aiding in the malleability of the alloy, while the copper gives it hardness and strength.

Gold-Platinum Alloys - These usually contain copper and silver also, and are used where hardness, resiliency, strength, and extreme resistance to corrosion are required, such as in making clasps and other parts of prosthetic appliances. The melting points of these alloys are all lower than that of pure platinum, but higher than that of pure gold.

Other Gold Alloys - Many of these are known. As a matter of fact gold alloys with most metals so readily that care must be used in the heating and working of gold to prevent its contamination by other metals. We have already mentioned the fact that very slight amounts of such metals as zinc or lead will destroy the malleability of gold and make it decidedly brittle. This is of very great practical importance to us as dental technicians. For example, in swaging gold plates on zinc dies with lead counter-dies, the plate must be carefully protected against actual contact with the lead or zinc by the use of sheets of thin paper, and cleaned with acid before annealing to prevent particles of lead and zinc from alloying with the gold. Such contamination with resulting brittleness would, of course, make it impossible to work the gold without fracture.

The so-called white gold used extensively by jewelers is an alloy of gold with either nickel or palladium, both of these metals masking the yellow color of the gold very effectively.

SILVER

Silver has been known from earliest time, and together with gold has always been classed as a precious metal. It is often found in the native form embedded in rock in the form of flakes, and occasionally is found in large masses or nuggets. It occurs in many minerals in the form of compounds from which it is separated by various processes. Mexico is the leading silver-producing nation with the United States coming second. Canada, Peru, Chile, and Australia also produce large quantities of silver. The price of silver is relatively low, fluctuating between 35 cents and 70 cents per ounce.

Pure silver has a very high luster and a beautiful white color. It is very malleable and ductile. It is probably the most ductile of any of the metals, and possesses this property to such a degree that it has been drawn into a wire so fine that one mile of it weighed only a gram. Silver is also the best conductor of electricity that is known.

Pure silver is difficult to cast because of the phenomenon known as "spitting" or "sprouting", which will be explained at this point. Silver

melts at 955 degrees Centigrade in the presence of air, or at 902 degrees Centigrade in the absence of air. This difference is due to the fact that oxygen is soluble in molten silver, 22 volumes of oxygen to one of silver, and this of course lowers the melting point of the metal. When the metal cools and solidifies, the oxygen dissolved in it is given up. However, when a molten mass of silver cools, the outside hardens before the liquid interior has lost its oxygen, and the latter forcing its way out as the cooling continues, breaks the crust of solid silver and ejects portions of the metal from the interior, thus producing very strange shapes. This is the "sprouting" or "spitting", and because of it, it is practically impossible to get a smooth and solid casting from molten silver that contains much oxygen. However, the solution to this problem is very simple. If the silver is melted under a borax flux with a reducing agent added, or if the molten metal is stirred vigorously with a pine stick before casting, the oxygen can be eliminated and smooth castings will be obtained.

Silver is quite resistant to serious corrosion, but is very susceptible to staining. Either of two agents will stain or darken silver. The first of these is ozone, which under certain conditions will form a black oxide with the metal. The other is certain compounds of sulphur, particularly hydrogen sulphide which is present in eggs, coal smoke, etc. These sulphur compounds form a black silver sulphide with the silver, and while the film of sulphide is very thin, it is very conspicuous because of its black color. Most silver alloys are subject to staining in the same way as the pure metal, especially if the silver content is high. Silver is readily soluble in either nitric or sulphuric acid, but is insoluble in most of the other common reagents.

Silver has a great many commercial uses, but in dentistry comparatively little of the pure metal is used. However, it is a very important constituent of many alloys used, and we should have a good understanding of its properties.

ALLOYS OF SILVER

Silver-Copper Alloys - These are used in greater amounts than any of the other silver alloys. Silver and copper are entirely soluble in each other in the molten state. The addition of small amounts of copper to silver lowers its melting point, makes it harder and stronger, but does not impair the malleability or color appreciably. The presence of copper also prevents the molten silver from absorbing so much oxygen, and prevents "spitting" on solidification. Most silver coins are silver-copper alloys, those of the United States containing 90 per cent silver and 10 per cent copper. Sterling silver is of practically the same fineness, containing 925 parts of silver per 1000 parts of alloy. It is used, of course, for making table ware and other things of a similar nature.

Silver-Tin Alloys - These alloys constitute the basis of the modern amalgam alloys used in filling teeth, but are little used in prosthetic dentistry. They usually contain from 67 to 70 per cent silver and from 26 to 29 per c ent tin. Silver amalgam alloys are made in the following manner. Each of the metal constituents is melted according to its melting point. The highest being melted first; followed by the next highest until all metals are fused. The molten mass is then poured into ingots which are cooled and filed. The filings are then passed through a magnetic field to s eparate the steel particles that have contaminated the alloy while being filed. It is bottled and labeled "Silver Amalgam Alloy."

Silver amalgam would then be, as according to definition, a mixture of this alloy or pure silver with mercury.

Silver amalgam Alloy:		Melting Point:
Silver	65%	955° C.
Tin	30%	232° C.
Zinc	2%	419° C.
Copper	3%	1083° C.

COPPER

Copper has been known from prehistoric times, and since it is found free in nature, it was probably one of the first metals to be used by man. Before iron was used so extensively, tools were usually made of bronze, which is an alloy of copper and tin.

Native copper is found in large quantities in northern Michigan, and smaller deposits are found in numerous other localities. In addition to the native state, copper is found in a wide variety of compounds such as sulphides, oxides, carbonates, and silicates, from which it must be extracted. The most important copper producing regions in the United States are Utah, Montana, Arizona, and Michigan. Canada, Chile, and South Africa are also very important producers of copper, but about half of the world production comes from the United States. Copper is cheap, the price at the refineries being from 10 to 20 cents per pound.

Copper is a heavy metal having a characteristic reddish color. It is very malleable and ductile. Copper is considered to be one of the medium hard metals, but its hardness varies with conditions of working.

Cast or annealed copper has a Brinell hardness of about 35, but cold worked copper has a Brinell hardness of over 100. Cold work also greatly increases the t ensil strength, hard-drawn copper having about twice the value in this property that annealed copper has. Copper is an excellent conductor of electricity, being exceeded only by silver in this respect. It dissolves readily in nitric and sulphuric acids, and

in the presence of air most acids act upon it slowly. When the air is moist, even the carbon dioxide present in the air will cause a green coating to form upon the metal. Hydrogen sulphide also attacks copper forming a black sulphide.

Pure copper melts at 1083 degrees Centigrade. Molten copper possesses the property of absorbing gases such as carbon monoxide, sulphur dioxide, and oxygen, particularly at high temperatures. Because of this, copper should be melted under a flux, such as a mixture of salt and borax, when it is to be cast or alloyed. Copper which has dissolved appreciable amounts of the oxide is harder than the pure metal, but is less malleable and less ductile.

ALLOYS OF COPPER - Copper alloys readily with a large number of metals, but we shall consider only the most important ones, and those which we use in dentistry. We have already considered the gold-copper alloys and the silver-copper alloys under the sections on gold and silver, so it will not be necessary to repeat. In alloys containing gold, silver, and copper, the copper is present in relatively small amounts, its purpose being to make the gold or silver harder and stronger.

There is another group of copper alloys spoken of as the high copper alloys, in which copper is the predominating metal. The most important of these are brass, bronze, nickel silver, and aluminum bronze.

Copper-Zinc Alloys - These alloys are the metals commonly known as BRASSES. There are a number of different brasses, all of them being composed of the same two metals, but varying in certain physical properties because of the different percentages of the copper and zinc used. The zinc content of brass varies from 2 to 45 per cent, while the copper content varies from 55 to 98 per cent. Commercial brasses are all harder and stronger than pure copper, but are less malleable. The hardness and brittleness increase as the zinc content increases. Brass composed of 55 per cent copper and 45 per cent zinc is quite brittle, and practically non-malleable and non-ductile. Another brass, called Alpha brass contains less than 37 per cent zinc, has a red or yellowish gold color, is medium soft, and is quite malleable and ductile.

Copper-Tin Alloys - These alloys are called BRONZE, and in many ways are similar to brass. Bronze contains from 2 to 25 per cent tin, and from 75 to 98 per cent copper. The bronzes are much harder and stronger than the brasses, but are also more expensive. Bronze is more resistant to corrosion than is brass.

Gun-metal and bell-metal are both good examples of bronzes. Gun-metal contains about 10 per cent tin, while bell-metal has a tin content of about 20 per cent. The brittleness of these alloys increases with the percentage of tin, and bronze which contains more than 25 per cent of this metal is so brittle that it is useless for all ordinary purposes.

Nickel silver is a Copper-Zinc-Nickel Alloy and is ordinary brass to which nickel has been added. One of the best nickel silvers is composed of 50 per cent copper and 25 per cent each of zinc and nickel. This alloy has a color similar to that of silver, is resistant to tarnish, is quite hard and yet malleable. It is used as a base for plated table ware, for special plumbing and hardware, and for certain instruments and tools.

PLATINUM

Platinum is another of the noble metals and is comparatively rare and expensive. It is found chiefly in the metallic state in the form of flattened grains of various sizes. Nuggets are only occasionally found. It is never found in the pure state, usually being combined with iridium, palladium, osmium, rhodium, gold, iron, copper and silver.

From 1825 to 1845 platinum was used for making coins in Russia, and at that time was much cheaper than gold. However, due to its increased use by jewelers, chemists, etc., the price rose until by 1918 it was worth more than 5 times as much as gold. By 1930 the price had declined to $57.00 per ounce, and by 1931 to $29.00 per ounce. The most important deposits of platinum are found in the Ural mountain district in Russia, in Columbia, South America, and in South Central Africa. In 1929 the entire world production amounted to only 200,000 ounces. It has been estimated that the dental profession alone uses some 60,000 ounces each year.

Platinum is a white, dense metal with a specific gravity of 21.4 which is one of the highest of any of the metals. Its color is not as white as silver, as it has a grayish or bluish tinge. The melting point of platinum is 1755 degrees Centigrade which is so high that it requires the use of an oxy-hydrogen flame or an electric furnace.

Platinum is one of the medium hard metals, having a hardness of about that of silver. It is quite strong, and is extremely malleable and ductile. In ductility it is second only to gold and silver, and can be drawn into wire of almost microscopic fineness.

It has been stated that a cylinder of platinum one inch in diameter and five inches long, could be drawn into a wire long enough to encircle the earth at the equator.

The thermal and electrical conductivity are less than that of gold. The coefficient of thermal expansion is very nearly the same as that of glass and porcelain, and for this reason platinum wire and posts can be baked into these materials with little danger of it causing cracks due to shrinkage or expansion with change in temperature. This point is of great importance in the construction of porcelain jacket crowns and operations of a similar nature.

Platinum alloys readily with most metals when hot, and therefore is very easily contaminated. In fact, when it is heated in an atmosphere containing traces of phosphorous, arsenic, antimony, and a few others, it will absorb sufficient amounts of any of these materials to cause extreme brittleness. Platinum absorbs enormous quantities of hydrogen even in the cold state, and when melted absorbs oxygen as well. The oxygen is expelled during solidification and causes "spitting," which was fully discussed under silver.

Platinum, being a noble metal, is resistant to corrosion in air and most of the ordinary liquids at all temperatures. It dissolves in aqua regia like gold, but when alloyed with large amounts of silver, it will even dissolve in nitric acid while gold will not.

The weldability of platinum is excellent as a weld can easily be produced at red heat with only a slight pressure. When soldering platinum, pure gold is ordinarily used as the solder, and because neither metal will oxidize at the soldering temperature, no flux is necessary.

ALLOYS OF PLATINUM - There are a number of these of varying impportance, the ones with which we are concerned being the gold-silver-platinum group. These have already been considered under the alloys of gold and of silver, so the only other platinum alloy of much importance to us is the platinum-iridium alloy.

Platinum-Iridium Alloys - The addition of iridium to platinum increases its hardness, strength, and elasticity very materially. The melting point of this alloy is higher than that of pure platinum. One of the most important uses of the iridium-platinum alloys is in the manufacture of hypodermic needles. An alloy of this type containing from 5 to 15 per cent of iridium is sometimes used for dowels in crown and bridge work.

MERCURY

Mercury is found both in the free and combined states. Native mercury, or quicksilver, occurs in several localities. But the most important source of this metal is from the ore, cinnabar. Spain, Italy, and the United States are the chief producers of mercury, but it is found also in China, Mexico, and Peru. The richest and most productive mines in the world are located near San Jose, California, and at one time yielded more than 3,000,000 pounds annually.

Mercury, or quicksilver, as it is commonly called, is a silver colored metal which is a liquid at ordinary temperatures. At a temperature of -38 degrees Centigrade it freezes to a solid that is malleable and ductile. It volatilizes slightly at ordinary temperatures, but as the temperature increases it volatilizes more rapidly. It boils at 357 degrees Centigrade, and is completely volatilized leaving no residue.

Mercury is not truly a noble metal, but is usually classed as one because it acts as one in so many ways. It is quite resistant to tarnish in ordinary air, but becomes darkened by hydrogen sulphide due to the formation of the black sulphide. It will not dissolve in acids with the evolution of hydrogen, but it will dissolve in either nitric or sulphuric acids and form certain mercury salts. The specific gravity of mercury is 13.6.

Pure mercury has a very bright appearance, is very fluid and mobile, forms perfect globules which leave no trace when rolled across a sheet of white paper. The presence of impurities in mercury are indicated by the metal having a dull appearance, by the fact that it is not as fluid as it should be, and seems unable to form perfect globules. If run across white paper, it will tend to drag and will also leave a trace on the paper. If it is very impure, a black powder will actually be deposited in the bottle containing the mercury. Lead, tin, zinc, and bismuth are the usual foreign materials that contaminate it.

Mercury vapor, and all of the soluble compounds of mercury are poisonous, excessive exposure to them, leading to serious mercurial poisoning. The medical profession uses mercury in various forms for the treatment of certain diseases. Commercially it is used in chemical laboratories and in the construction of thermometers, barometers, manometers, etc.

In dentistry the main use of mercury is in the formation of amalgams which are used extensively as filling materials. In the laboratory amalgams are used for packing dies in the construction of porcelain jacket crowns and in the indirect method of making inlays and crowns.

Vermilion is a red, crystalline, mercuric sulphide which is used as a coloring matter to color dental rubbers, waxes, etc. Mercuric chloride, or corrosive sublimate as it is sometimes called, is often used in solution as a sterilizing material. However, such a solution may corrode the metal of which the instruments are made and ruin the cutting edges. This is particularly true in the case of instruments made of nickel, copper, and steel.

ALLOYS OF MERCURY - The alloys of mercury are called AMALGAMS. An AMALGAM is an alloy of two or more metals, one of which is mercury.

Dental amalgams used for filling purposes are combinations of mercury with silver, tin, copper, and zinc. The American Dental Association specifications require that such an alloy must contain from 65 to 70 per cent silver, 26 to 29 per cent tin, 3 to 6 per cent copper, and 0 to 2 per cent zinc. A few of them contain small amounts of gold and platinum.

Copper amalgams are used in dentistry especially as filling materials in the deciduous teeth of children. This amalgam is very hard and strong, hardens with practically no change in volume, and is said to have some

germicidal action. However, it tarnishes rapidly in the mouth due to the formation of the black copper sulphide, and it stains the tooth structure. Copper amalgams have the unique property of again becoming plastic when heated and ground in a mortar.

Gold and mercury have a high affinity for one another. Gold often absorbs mercury from amalgams with which it comes in contact. If much mercury is absorbed by the gold, the desirable properties in the gold will be destroyed, so small particles of mercury should never be carelessly left on a bench at which gold work is being done as the gold will quickly take up any mercury with which it comes in contact. Many rings worn by dental assistants have been ruined because the assistant forgot to remove it when mixing amalgams for the dentist.

Sometimes inlays and crowns are swaged on amalgam dies, and when this is done the crown or inlay should never be left on the die, as the gold will absorb enough mercury from the die to ruin it.

Mercury forms amalgams with many other metals, but as they are unimportant in our work, a discussion of them would only prove confusing, and be of no practical value, so we will consider amalgams no further.

LEAD

Lead is a very abundant and very useful metal that has been known and used since early times. It is usually never found in the free state, being obtained mostly from the ore Galenite, which is lead sulphide. Galenite is found in the United States, Great Britain, Spain, and Saxony. In 1929 the United States produced about one third of the world's output of lead, Missouri, Idaho, and Utah being the chief producing states. Lead is cheap, the price varying from 6 to 10 cents per pound.

Lead is the softest and least tenacious of any of the metals in common use. It is very malleable and ductile, but because of its low tenacity it can be drawn into fine wire only with great difficulty. Lead is bluish-gray in color and has only a slight luster. It melts at 327 degrees and boils at 1620 degrees Centigrade. Lead will corrode to some extent. It dissolves slowly in hydrochloric acid, but rapidly in nitric acid.

ALLOYS OF LEAD - Lead alloys with many metals, the alloys formed usually being harder but less malleable than pure lead. There are a few metals, notably aluminum, zinc, chromium, nickel and cobalt, with which lead does not alloy well. The most important of the lead alloys are those with tin, antimony, arsenic, or some combination of these.

Lead-Tin Alloys - Lead and tin form a number of alloys, the melting points of which are all less than that of pure lead. The properties of these alloys vary depending on the composition, but generally speaking

they are harder than lead and quite malleable, although not as much so as the pure metal. Soft solders are lead-tin alloys.

Fine solder is composed of one part of lead and two parts of tin, and the melting range is from 181 to 190 degrees Centigrade.

Common solder is composed of one part of lead and one part of tin, and the melting range is from 181 to 220 degrees.

Coarse solder, is composed of two parts of lead and one part of tin, and the melting range is from 181 to 260 degrees. This is the solder used by plumbers as a wiping solder since it has a pasty range of about 80 degrees.

Old pewter was a lead-tin alloy, but the present day pewters are usually made of copper and tin. The tin content usually runs very high, being from 80 to 90 per cent.

TABLE V - LOW-FUSING ALLOYS WITH PARTS BY WEIGHT OF EACH

INGREDIENT AND MELTING POINT OF THE ALLOY.

NAME OF ALLOY	LEAD	TIN	CADMIUM	BISMUTH	MELTING POINT Deg. F.
BROPHY'S	2 3/4	$2\frac{1}{2}$	0	3	240
NEWTON'S	2	3	0	5	212
MELOTTE'S	3	5	0	8	205
ROSE'S	3	3	0	6	203
RICHMOND'S	5	3	0	8	202
ERMAN'S	1	1	0	2	199
CROUSE'S	5	5	1	8	190
HARPER'S	4	4	1	7	180
MERCK'S	25	25	20	55	162
WOOD'S NO. 1	2	1	1	4	155
WOOD'S NO. 2	20	40	26	96	135
MOLYNEAU'S	3	2	2	5	140

NOTE: - In making these alloys the metals must be melted according to the above arrangement: that is, melt the lead first, when completely fused, add the tin, then the cadmium and finally, under constant stirring and with a low flame, add the bismuth.

HEAT TREATMENT OF METALS AND ALLOYS

The properties and structure of many metals and alloys can be greatly changed or modified by some heat treatment. In many cases the properties of metals and alloys can be changed at will, and can thus be adapted for the purpose at hand. The crystal size can be changed, and

strains can be relieved by a proper heat treatment. However, all metals and alloys are not responsive to heat treatment, and those that are, require very different handling in the matter of temperatures, time, etc. Heat treatment includes the processes of annealing, hardening, and tempering.

ANNEALING - This is the process whereby strains in the metal which have been produced by cold working are removed, the grain refined, and the softness, malleability, and ductility are restored. Annealing consists of heating the metal or alloy to a certain temperature and holding it there for a short time. Care must be taken not to apply too much heat as metals annealed at too high a temperature becomes grainy.

As stated previously there is a great difference in the heat treatment of various metals and alloys. The gold alloys which we use are usually annealed or softened by heating to a red heat and plunging in cold water. This same treatment has the opposite effect on steel, as this metal attains full hardness by being heated to red heat and plunged into cold water. Steel can be softened by slowly reheating the hardened piece, but gold-copper alloys are hardened by this process.

HARDENING - This is the process wereby metals which have become softened by annealing are hardened by the proper application of heat. In the case of gold-copper alloys, hardening is accomplished by heating the metal to a red heat and allowing it to cool slowly in the air. Steel is hardened by heating to red heat and plunging in cold water.

If a certain alloy is properly annealed, it becomes soft, malleable, and non-elastic. If it is slightly hardened, it becomes more springy, harder, and less malleable. If it is still further hardened, it becomes very elastic and resilient, much harder, and practically non-malleable. It also become slightly brittle. If the metal is completely hardened it becomes very hard and very brittle. This shows that the elasticity, resiliency, and tenacity increase as the hardness increases up to a certain point, but that when carried beyond this point brittleness appears and with it loss of elasticity, resiliency, and tenacity. The hardness obtained can be controlled by the application of the proper amount of heat and the proper method of cooling.

TEMPERING - This is the process whereby a fully hardened metal such as steel can be made softer, more elastic or springy, and stronger. It is accomplished by reheating the hardened steel and as it cools quenching in water at the proper temperature to give it the desired properties.

The heat treatment of most metals and alloys varies considerably. We shall consider more in detail the heat treatment of the gold alloys with which we are concerned. This will be explained later when the processing of gold is studied.

The non-metallic materials used in the laboratory may be divided into (1) Setting materials, (2) Waxes, (3) Plastics (denture base materials) and (4) a list which may be grouped under Miscellaneous.

The Setting Materials

The setting materials may be divided into groups depending upon their use in the laboratory. Model materials, impression materials, investment materials and cements. In many cases we find that a material might be classified under one or more headings.

Model Materials

A model or cast is a positive reproduction of an object impressed and poured up in Plaster of Paris or a similar material.

In order to better understand these materials we should first study the reasons for their development by the manufacturers and the requirements necessary for a good material.

CAST OR MODEL MATERIALS

The materials from which casts are made are nearly all gypsum products. Many manufacturers produce such products, each with its own trade name.

There are several things that we require in a good cast or model material, the more important ones being as follows:

1. They must have great strength against compression, or great crushing strength.

2. They should be dense and non-porous.

3. They should have smoothness of surface.

4. They should have a low expansion index.

PLASTER OF PARIS

Plaster of Paris gets its name from the fact that it was first made from gypsum taken from the quarries of Montmarte, near Paris.

GYPSUM, or Selenite, is a hydrated calcium sulphate whose chemical formula is $CaSO^4$ .2H2O. When gypsum is heated to a temperature slightly above that of boiling water, three fourths of its water of crystallization is driven off, the hydrate thus formed constituting Plaster of Paris. The formula of the hydrate is ($CaSO^4$) 2H2O.

DENTAL PLASTERS are prepared from the purest and specially selected gypsum. Every step in the manufacturing process is carefully controlled to assure uniformity of quality in the finished product.

Plaster is used in dentistry for taking impressions of the mouth and teeth, for making models, for flasking cases preparatory to vulcanization, and as an ingredient of various investments.

Plaster of Paris is a fine white powder. It becomes plastic in the form of a thick paste when water is added and becomes hardened by crystallization. Plaster usually sets or hardens in from 2 to 5 minutes, depending on conditions of quality, temperature, mixing time, etc.

The MIXING OF PLASTER is very important. The proper amount of water is placed in a rubber bowl and the plaster is sifted into the water until the powder forms an island in it. By doing this, the water is enabled to take up the plaster slowly and evenly and eliminates the formation of lumps. The spatula is next employed and the mass is thoroughly and smoothly mixed. The mixture should be smeared against the sides of the bowl to break up any possible lumps, and whipping should be avoided as this will incorporate air and cause bubbles. At best a certain amount of air will be trapped, and for this reason the bowl should be frequently jarred against the bench to help eliminate any bubbles that might have been formed.

The finer the plaster and the longer the mixing time, the quicker the setting time will be.

The coarser the plaster and the more water used, the slower the setting time will be.

Hasteners or accelerators such as salt, or warm water will cause a quicker set by nearly 50 per cent, and will also decrease the amount of expansion.

NEVER add water to a mix and remix after setting has started, as this breaks up the crystals and adds excess moisture, producing a weak plaster.

Plaster does not reach its maximum hardness until it has lost its excess moisture. When all uncombined water is lost, plaster has a crushing strength of nearly 1500 pounds per square inch. However, when the water of crystallization is lost due to high temperatures and prolonged drying, the strength of the plaster is greatly reduced.

Plaster of Paris, on standing a long time, loses much of its life or plasticity, and on mixing with water does not come to a smooth, creamy consistency, but becomes granular and feels dead and coarse. In addition, the amount of water that must be added to the plaster to bring it to the proper working consistency decreases about 15 or 20 per cent. The time of setting is also greatly affected by aging. If plaster is allowed to become damp a certain amount of the moisture from the air will combine with the powder and will show in the form of lumps. Such contamination greatly damages the plaster as its setting time is accelerated, its strength is decreased, and its smooth working properties are destroyed.

For these reasons plaster should be kept in a dry place and in closed containers.

The strength of plaster is very greatly affected by the amount of water used in mixing it. The stiffer the mix, the greater will be its resultant strength. The setting time of plaster does not exert any appreciable influence on its strength. In fact, it has been noticed that very slow setting plasters which during the setting process develop fairly large gypsum crystals, are generally weaker than similar plasters accelerated to a quick set, with consequent rather small crystals.

Potassium sulphate is ordinarily used as an accelerator in the manufacture of most impression plasters. This salt does not appreciably reduce the strength of the plaster unless added in amounts of over 0.50 to 0.75 per cent. Potassium sulphate not only decreases the setting time, but also decreases the setting expansion of plaster.

The SETTING TIME is the period required for Plaster of Paris to harden after the addition of the plaster to water. The setting time is divided into two stages, the initial and final.

The Initial Setting Time indicates the length of time the plaster may be worked or molded.

The Final Setting Time indicates the length of time which must pass before the plaster cast is hard enough for use. The final setting time is not the point of maximum strength, as this is not arrived at for several days, or until all excess moisture has been lost.

ACCELERATORS AND RETARDERS - Accelerators are substances added to the mix which cause the plaster to set more quickly. The most common accelerators are potassium sulphate, sodium chloride (common table salt), and warm water.

Retarders are substances added to the mix which slow up or retard the setting time of the plaster, and allow a longer manipulation time. Substances commonly used for this purpose are alum, vinegar, or acetic acid. Powdered marshmallow root is also used, and has the additional advantage of having a pleasant taste.

Plaster of Paris is frequently used in taking impressions of the mouth and teeth. When this is done the impression must be broken and removed in pieces, because the plaster, being rigid, will not draw over any existing undercut areas about the teeth. The pieces are reassembled in the tray and waxed together, a separating medium is applied, and the model poured with a suitable model material. When the model is separated from the plaster impression great care must be exercised. The plaster of the impression must be chipped off or cut off in small sections, and if carelessly done will result in damage to the cast due to cutting through into it, or in breakage of the teeth due to force applied in trying to pry off sections of the impression material.

A plaster-like impression material was devised which side-stepped one of the bad features of ordinary plaster. With this new material, after the cast was poured and ready to separate, the whole thing was placed in boiling water and the impression material simply disintegrated and fell off leaving the cast intact. These impression materials are nothing more than a DISINTEGRATING PLASTER which is ordinary plaster of Paris with a certain percentage of potato starch added to give it the property of breaking down under boiling. SOLVITE is one of the better known of these commercial preparations, and has enjoyed a wide popularity.

Disintegrating plaster can easily be made from the following formula:

Plaster of Paris . . . . $7\frac{1}{2}$ parts by weight.
Potato Starch . . . . $2\frac{1}{2}$ parts by weight.

Two other commonly used model or cast materials that are used and that are in reality superior to Plaster of Paris for this purpose are Artificial Stone and Quick Setting Stone.

ARTIFICIAL STONE - In past years a material known as artificial stone was commonly used. This product was oxychloride of magnesium, a mixture of magnesium oxide and magnesium chloride. This material meets all our requirements to a very high degree. It has a crushing strength of nearly 15000 pounds per square inch, or about 10 times that of plaster. Its expansion is only about 1/4 that of plaster, and it is also very smooth, dense and non-porous. However, it has one very big disadvantage in the fact that it takes 12 hours or more for the final set. It is mixed very thick (about the consistency of putty), and is packed into the impression in small pieces. Artificial stone is still on the market but is little used at the present time, having been replaced to a large extent by the so-called quick setting stones.

QUICK SETTING STONES - These are all gypsum products containing hasteners to cause quick setting. These materials are mixed like plaster except that they are mixed somewhat thicker. They set in about 15 minutes generating considerable heat during the crystallization. The setting expansion is only about 1/3 that of plaster, and varies with the different products from 0.1 to 0.2 per cent. The crushing strength is also much higher than that of plaster ranging from 3000 to 4000 pounds per square inch in from 1 to 24 hours. After seven days when the dry state is reached the crushing strength increases to 7000 pounds per square inch or more. The quick setting stones come in various colors from white to blue and brown, each characteristic of its own manufacture. They are best mixed in proportions of 100 parts of powder to 30 parts of water by weight. The stones, like any other model material, should be carefully placed in the impression in small quantities and jarred or vibrated thoroughly to eliminate air bubbles.

	Expansion	Setting Time	Crushing Strength
Plaster of Paris	.3 to .6%	2-4 mins. 10-20 mins.	1500 lbs.
Quick Setting Stone	.1 to .15%	15-30 mins.	3000 to 5000 lbs.
Artificial Stone	.07 to .095%	10-12 hours.	15,000 lbs.

From the above chart you can easily see that Plaster of Paris is not an ideal material for models and casts.

Refractory materials are primarily those substances that are resistant to high temperatures. They are used as investments for casting gold inlays, clasps, crowns and one-piece castings. Other types are used only for soldering purposes. Still others can be used for the making of electric furnaces, crucibles, etc. Generally speaking they are composed of a refractory material and a binder. The binders are used to set the material; a common binder often used is Plaster of Paris. The refractory material is usually some form of silica.

Commercial products that are in common use for casting and soldering purposes are:

a. Cristobalite Investment: Is made up of Plaster of Paris and cristobalite, which is a distinct form of silica that has a high coefficient of expansion. This form is excellent for inlays and crowns.

b. Cristobalite model Investment: Is made up of Plaster of Paris, cristobalite, and other materials. This gives a harder model that is easier to work for large one-piece castings, such as removable bridges, etc.

c. Imperial Investment: This is a quick setting investment that gives a hard working model. It is primarily used for soldering purposes.

BASE PLATE WAX

Base plate wax is used mainly to build occlusal rims on the trial denture base and to hold the teeth in position for the try-in. The occlusal rims, or bite rims as they are sometimes called, take the place of the teeth in the trial denture, before the teeth are arranged and articulated.

This wax must have certain properties if it is to serve our purpose satisfactorily.

1. It must be of a hard variety so that the teeth will be maintained in position, yet not brittle so that they will be knocked out or broken off from stress during the try-in of the denture.

2. It should not soften at mouth temperatures, and should not mash down or change shape under such stress as may be applied during the try-in.

3. The color of the wax should contrast with the color of the teeth so as to aid in contouring and shaping. The color is practically always pink or red.

Base plate waxes are composed mainly of beeswax, paraffin, and coloring matter. Some manufacturers include a little resin also. The ingredients are melted together, cast into thin blocks and then rolled into thin sheets, in which form it is put on the market.

Several formulae for base plate wax are given below. In each case the parts given are by weight.

Formula # 1		Formula # 2	
White Beeswax	40 parts.	Yellow Beeswax	50 parts.
Gum Turpentine	10 parts.	Gum Mastic	6 parts.
Cotton-seed Oil	3 parts.	Prepared Chalk	3 parts.
Vermillion	4 parts.	Vermillion	4 parts.

Formula # 3

Resin	1 part.
Cerecin	3 parts.
Paraffin	6 parts.

STICKY WAX

Sticky wax is a wax that has adhesive properties. A good example of its use is in a denture repair. Here it is used to hold the parts together until a new model may be poured up.

Sticky waxes are composed of beeswax, paraffin and a high percentage of resin. It is the resin which gives the wax its great adhesiveness and hardness. Coloring matter is sometimes added, the color varying with the different manufacturers. The materials are melted together as in the case of the base plate waxes, but are cast into sticks, in which form they are sold to the dental profession.

Three formulae for sticky waxes are given below, and here again the parts shown are by weight.

Formula # 1

Gum Dammer	1 part.
Resin	16 parts
Yellow Beeswax	8 parts.
Vermillion	1 part.

Formula # 2

Yellow Beeswax	4 parts.
Resin	1 part.

Formula # 3

Yellow Beeswax	1 part.
Resin	3 parts.

There is considerable difference in these formulae and various types of sticky wax will be produced. Those having the higher percentages of resin will be the hardest and the most brittle. Those with smaller resin percentages will be softer and will tend to bend rather than break.

Inlay and Casting Wax.

Inlay and Casting Wax is a wax that is used in preparing patterns of inlays, crowns, etc. A good Inlay and Casting wax has the following properties:

1. The expansion must counteract contraction of gold.
2. Melting point above mouth temperature.
3. Rigid enough to allow drawing of patterns.
4. Color must contrast.
5. Easy to carve.

These waxes usually contain a mixture of commercial waxes such as paraffin, carnauba, ceresin beeswax, and coloring.

Utility Wax

Utility wax is tacky but pliable at room temperatures. It is used for extension of trays, carding teeth, etc.

Boxing Wax

Boxing wax is a wax somewhat similar to utility wax, but not so sticky and has a slightly higher melting point. Its chief use is boxing in impression in place of tin or other boxing materials.

BASE PLATE MATERIALS

A BASE PLATE is a temporary denture base, used only to hold the teeth during their arrangement and trial in the mouth, and must not be confused with the denture base which is permanent.

There are four requirements which a base plate material must fulfill

1. It should be rigid and unyielding.
2. It should be capable of withstanding the temperature of the mouth without softening or bending under stress during trial.
3. It should be capable of close adaptation.
4. It should not be heavy so that it will become dislodged by its own weight.

There are many of these commercial base plates on the market, each with its own trade name, but they are all composed mainly of resins whose properties have been modified with wax. These base plates are softened, usually by dry heat, molded over the cast and trimmed. Some of the poorer products will warp and bend, but the better ones will break rather than bend.

There are three main types of base plate materials:

a. Shellac base and a wax. (most commonly used).

b. Vulcanite base plate, which is a lengthy procedure requiring the waxing and vulcanizing of the base plate.

c. Acrylic.

STAINING MATERIALS

Staining materials are used where plaster impressions have been taken, or when a second pouring of plaster or a similar material is necessary against a previous pouring.

Whenever a plaster impression material has been used and before a cast is poured from it, a staining fluid is painted over the surface of the impression. This stain penetrates the plaster from one to two millimeters in depth. Then in separating and cutting the plaster of the impression from the model, the stained portion will indicate the approach to the line of demarkation between the two, and thus help prevent injury to the cast. Staining materials are applied only to plaster impressions as the other types of impression materials do not require this treatment since they are softened and removed with heat.

A staining fluid should be capable of penetrating either moist or dry plaster to a depth of one or two millimeters.

Since its purpose is only to stain, it should be completely absorbed by the plaster to which it is applied, and should not form a film on the surface. Staining materials may be either aqueous or alcoholic solutions.

A thin alcoholic solution of orange shellac is commonly used. Aqueous, or water solutions of aniline dyes can also be used and give good results.

SEPARATING MATERIALS

A separating material is used to prevent the adhesion of the cast material to plaster. It is used wherever plaster is being added to a previous mix of plaster and we expect to separate the two. The surface of a plaster impression must be painted with a separating material, otherwise it would be impossible for us to separate the cast from the impression itself.

A good separating material should have the following properties:

1. It should be impervious to moisture after being applied and dried.

2. It should not modify the areas it covers, and should be effective in thin applications.

3. It should present a smooth glazed surface when dried.

4. It should be sufficiently adhesive to stick to the applied surface and should not peel off.

Separating materials are divided into the following four classes:

1. Alcoholic Solutions
2. Ethereal Solutions
3. Aqueous Solutions
4. Oils

1. ALCOHOLIC SOLUTIONS - These are made by dissolving certain substances in alcohol. Sandarac varnish is the best example of an alcoholic solution used for a dental separating medium. It is made by dissolving 6 ounces of sandarac in 24 ounces of grain alcohol. Sandarac varnish is probably the best all around separating material that we have.

2. ETHEREAL SOLUTIONS - These are solutions of various substances in ether. Collodion and soap are examples of this class. Collodion is a solution of gun cotton in ether, and is a thin, colorless, syrupy liquid smelling strongly of ether. Because it evaporates and thickens very rapidly, it is almost impossible to apply it smoothly and evenly enough so that the covered surfaces are not modified, and for this reason cannot be used to good advantage where accuracy is required. Solutions of soap in ether are sometimes used.

3. AQUEOUS SOLUTIONS - These are water solutions of various materials. An ordinary solution of soap and water makes a fair separating medium.

$\frac{1}{2}$ pound of borax dissolved in 1 gallon of water, to which is added $\frac{1}{2}$ pound of ordinary brown shellac flakes makes a good separating material of the aqueous group.

Another fine and inexpensive material belonging to this group is sodium silicate. A water solution of sodium silicate is the substance usually called water glass, A small amount of coloring matter is often added to make it easier to see where the medium is applied.

4. OILS - These are not considered good separating materials. Paraffin oil, vaseline, and lard are included in this class, but do not spread well over plaster and tend to modify the covered areas considerably. They should be used only when nothing else is available. They should never be used on plaster impressions as they do not have the faculty of entering small crevices.

IMPRESSION MATERIALS

The first and one of the most important steps in the chain of procedures leading to the successful construction of a denture is a good impression. It is from the impression that the cast is made, and it is the cast upon which the denture is constructed. Therefore, it can readily be seen that an error in the impression will be carried all the way through the various steps, and the end result will be an ill-fitting denture. In other words we cannot expect a denture to fit unless we have an accurate impression to start with.

There are several things which we require of a good impression material, the more important ones being as follows:

1. It should be composed of materials which are not unduly disagreeable to the patient.

2. It should become plastic at a temperature which the oral tissues can tolerate.

3. It should copy accurately the fine lines and irregular surfaces to which it is applied, and should retain its form on removal without becoming distorted.

4. It should not expand, contract, or warp at ordinary temperatures.

5. It should harden in a reasonably short time, that is, in from one to three minutes.

There are two types of impression materials.

1. Those rendered plastic by the addition of water and which harden by crystallization.

2. Those which are made plastic by the application of heat and which harden on cooling.

Plaster of Paris and similar materials come under the first type, while all other materials come under the s econd type.

Materials generally used for impression taking are Plaster of Paris, impression compound or modelling compound, and the newer or so-called elastic materials.

PLASTER OF PARIS - We have already studied plaster of paris quite thoroughly under Cast Materials, so it will not be necessary to repeat at this point. Impression plaster is merely a high grade of plaster to which accelerators have been added to control the setting time. The plaster is put in a tray and while in the plastic state is inserted in the mouth. When it becomes hard, the tray is removed and the plaster impression is broken and removed in sections. The pieces are reassembled in the tray and waxed together.

A SEPARATING MEDIUM MUST ALWAYS BE APPLIED TO A PLASTER IMPRESSION BEFORE THE CAST IS POURED.

Plaster has certain advantages and disadvantages. Its greatest advantage lies in the fact that it reproduces perfectly the undercut areas about the gum tissue and the teeth with no chance of distortion. On the other hand, because of its soft plastic state when inserted, it gives an impression of the tissue at rest and makes no allowance for the compressibility of the tissue. It is very messy to handle, and is more or less disagreeable to the patient. It is commonly used for partial denture impressions and from the standpoint of accuracy alone, no material is superior to it.

It is often used in conjunction with modelling compound as a wash in impressions for full dentures, and occasionally in taking sectional impressions.

MODELLING COMPOUND - This material consists of a waxlike mixture of resins and oils, well mixed with an inert filling substance such as French chalk together with flavoring and coloring matter. The exact formulae of these compounds are not known, being trade s ecrets of the various companies which manufacture them.

The object of a dental impression is to s ecure a model upon which a denture or appliance can be constructed that will produce substitutes for the lost teeth. This appliance must function without interfering with the surrounding tissues and organs, such as the tongue and cheeks. It must fit accurately and be closely adapted to the tissues, not only when they are at rest, but when they are tense and working, such as in mastication and talking.

Plaster was the original impression material. As we have seen it gives an extremely accurate impression of the tissues at rest, but gives no account of the tissues when under pressure and compressed to some extent. It was with this in mind that modelling compound was developed. It is so made that it allows for plasticity and mobility, but still has a yield or flow value that will allow for some compression. Modelling compound is far less messy to handle, and is not as objectionable to the patient as plaster. However, in partial cases where there are undercut areas, the impression has a tendency to draw or distort around the undercuts, and the result is an inaccurate impression. In cases presenting undercut areas it is not possible to obtain an accurate impression with modelling compound unless a special technique such as the sectional compound method is used. In this method the impression is taken in sections and the various parts are fitted together again after removal from the mouth. When this is done the undercut areas are fairly well reproduced, and the impression as a whole is quite accurate provided the various steps have been carefully carried out. NO SEPARATING MEDIUM IS USED AS A MODELLING COMPOUND IMPRESSION BEFORE THE CAST IS POURED. In separating the impression from the cast the compound is softened by placing it in hot water and is then peeled off.

Compounds made by various manufacturers vary somewhat in the temperature at which they reach the desired plasticity. Most of them reach the proper state when placed in water heated to 140 degrees F.

ELASTIC IMPRESSION MATERIALS - These are a comparatively new group of materials which have come into prominent use recently, and have proved to be very satisfactory.

These materials are all reversible hydrocolloids. A hydrocolloid is a substance disbursed in water in the colloidal state. A reversible hydrocolloid is one which can be caused to liquefy and to gelatinize or set, by the alternate application of heat and cold. In other words, it has the ability to pass from a semi-solid to a plastic and then back again.

By the colloidal state we mean that state in which a substance can exist intermediate between suspension and true solution. Glue and jelly are both examples of substances in the colloidal state.

The main ingredient of these materials is AGAR-AGAR, which is a mucilage-like substance extracted from sea weeds growing on the coast of southern and eastern Asia. These weeds are gathered, and the agar-agar is obtained by straining through cloths after which it is dried out. It comes in the form of long flat straws or in thin flat sheets. Most of it is imported from Japan, Borneo and Ceylon, although recently it has been grown off the coast of California. Other ingredients of the elastic impression materials are fibers, caoutchouc, zinc oxide, coloring and flavoring materials, antiseptics, oils and waxes. The exact formulae are not known as they are trade secrets of the various manufacturers, each one using his own materials and his own particular formula.

The fibers are used to give the material body and help hold it together. The oils and waxes serve to lubricate the mass and prevent it from adhering to the teeth and soft tissues. The coloring and flavoring, of course, make it more agreeable to the patient.

PROPERTIES OF THE ELASTIC IMPRESSION MATERIALS - At ordinary temperatures these compounds are firm, elastic jellies. When heated to about 212 degrees F. (boiling point of water) they become a thick liquid. When cooled they do not gelatinize at once, especially if stirred or worked while cool. The time of gelatinizing depends upon the temperature. At around 120 degrees F. they will remain liquid for about 45 minutes, at 100 degrees for about 10 minutes, and at 60 degrees for about one half minute. Thus it is possible to liquefy the compounds by boiling, reduce the temperature to slightly above that of the body (98.6), take the impression in a semi-liquid state, and finally cause gelatinization by cooling to 60 or 70 degrees F. It is important to remember that these compounds can hold heat for a long time, and that they should be properly cooled before being applied to the tissues, else serious burning may result.

These materials were originally put into a mixing or churning syringe and then placed in boiling water for a period of time. The plunger of the syringe was then worked up and down until the mass was thoroughly mixed and liquefied. By alternately putting the syringe in cool water and working the plunger, the mass was cooled to the proper temperature for impression taking. It was then placed in the impression tray and carried to the mouth. Before removal, the material was thoroughly chilled with cold water until gelatinization was complete. Recent techniques have been developed whereby it is not necessary to use a mixing syringe. In these the material comes in a celluloid capsule, and the capsule is placed directly in the boiling water, and when removed is kneaded in the hands until properly mixed. The celluloid capsule is then cut at one end, and the material is squeezed out into the impression tray.

The various materials differ somewhat in the length of time required for boiling, cooling, etc. Each product carries its own instructions for use, and it is especially important to follow closely the directions for the particular product being used.

Because of the elastic properties of these materials, impressions made from them will spring over undercut areas about the teeth upon removal, but will return to the proper shape and give a very accurate impression of the mouth and teeth including any existing undercuts. It is quite obvious that the great use for these materials is in obtaining impressions for partial cases in which some teeth still remain, and around which there are undercuts and irregularities of varying degree.

Elastic impression materials are used in laboratory work for the purpose of duplicating casts. If properly handled, these materials will produce an impression quite as accurate as plaster, and are much less disagreeable to the patient.

Dentocoll, SS. White Elastic Compound, Surgimould, Repelastic, and Elasticoll are all materials of this type.

NO SEPARATING MEDIUM IS USED ON IMPRESSIONS MADE FROM THE REVERSIBLE HYDROCOLLOIDS BEFORE POURING THE CAST. THE CAST SHOULD BE POURED AT ONCE AS THE IMPRESSION MUST NOT BE ALLOWED TO STAND AND DRY OUT. If this cannot be done, the impression should be wrapped in a damp towel and put in a cool place until it can be poured. As the impression is elastic it can easily be peeled from the cast without any further heating.

TRUELASTIC - This is not a colloid, but is an elastic impression material somewhat similar to modelling compound. It comes in the form of cakes like modelling compound, but is darker in color, and has a rubbery feel and an odor suggestive of chocolate.

It is composed of shellac, French Chalk, glycerine, stearin and coloring matter. The claims made for it are that it is of particular value in taking impressions where undercuts are present due to tilting and shifting of teeth. Truelastic is supposed to be pulled out of shape upon removal of the impression from the mouth, but is also supposed to return to its original shape and give an accurate impression.

The technique for handling it is as follow: It is softened by placing in water heated to 167 degrees F. and left there for one minute. It is then removed from the water and kneaded until the mass is uniform in consistency, placed in a tray, and carried to position in the mouth. After two minutes it is removed with a straight pull and chilled in cold water for five minutes or longer.

NO SEPARATING MATERIAL IS USED BEFORE POURING THE CAST.

The impression is removed from the model by placing in water at 116 degrees F. and then stripping or peeling it off.

DENTURE BASE MATERIALS

Requirements of a denture base:

a. Must have great strength with lightness of weight.
b. Must have permanence of form.
c. Must be dense so it will not absorb moistures or odors.
d. Must be tolerated by the tissues.
e. Must be durable.
f. Must have a pleasing and permanent color.
g. Its expansion and contraction must not be too great.
h. Must be easy to repair.
i. Must be easy to process.
j. Must adhere to metals and porcelain.
k. Must have a hard surface.

Denture Materials may be classified as

1. Vulcanites
2. Acrylics such as lucitone, Vernonite, Densine.
3. Metals - such as gold and chrome alloys.
4. Cellulose compounds - such as hecolite, parfait, which have so many undersirable features that they are not commonly used.

Vulcanite: This material is also known as hard rubber, and is chiefly composed of caoutchouc or raw rubber and sulfur. The coloring depends upon the addition of coloring materials such as sulfides of zinc, mercury, cadmium, and antimony. The greater amount of coloring used the weaker the denture base material.

Acrylic: Is a methyl methacrylate resin developed for dental purposes. It is a semi-solid organic substance, and its exact formula is a trade secret. It usually comesto us in powder and liquid. The main advantages of this material over vulcanite is its pleasing color, strength, lightness in weight. Its disadvantages are its contraction and repairability. Extreme care must be exercised in its manipulation. There are many other materials used in the laboratory, and some of these we will study later in the chapter on laboratory technics.

DENTAL ANATOMY

If we are to become successful dental technicians, it is essential that we know something about the mouth and teeth, as our work will deal entirely with these parts of the body. A jeweler with no knowledge of springs, gears, pinions, etc., would have no success in making or repairing a watch or clock; nor would a mechanic do very well in assembling an engine, unless he had a thorough understanding of the parts involved and the function of each of them.

We are not in the least concerned with watches or motor parts, but we are vitally concerned with teeth, and the better we understand them, the more sucess we will have as dental technicians.

Most of our work will deal with the construction of appliances which replace lost teeth and which must not only restore function, but must also be comfortable and have a pleasing appearance.

It is not necessary that a technician have the thorough knowledge of blood supply, nerve supply, etc., that is so essential to the dental surgeon, but he should possess a thorough knowledge of tooth form and tooth arrangement. He should also have some knowledge of the action of the various muscles involved in the process of chewing, so that the replacements which he constructs will function properly through all of the various movements of the jaw.

Throughout this course, it shall be our endeavour to make you understand why certain procedures are followed and why certain things are true, rather than to arbitrarily tell you to do this or that. All cases are not normal, and if the underlying principles are understood, you will be better qualified to cope with them.

Each tooth will be studied in detail as to form, markings, comparative size, function, and position in the mouth. For this purpose we shall use Black's Dental Anatomy which has been issued to you. In addition to this, models of teeth will be available in the class room which will be of further assistance. You will each be required to carve in wax a certain number of selected teeth upon which you will be graded.

*   *   *   *   *   *

A TOOTH is one of 32 specialized organs placed in the mouth, the chief function being to seize and masticate food, and by so doing prepare it for further passage along the alimentary canal.

The incisors, which are situated at the front of the mouth, have rather sharp edges, and their purpose is to incise or cut.

The cuspids and bicuspids are situated at the corners or angles of the mouth. They have fairly sharp points or cusps, and their purpose is to seize and tear the food.

The molars are situated in the back part of the mouth, and have broad surfaces containing a number of cusps. The function of the molars is to grind the food.

Teeth are sometimes roughly divided into ANTERIOR TEETH and POSTERIOR TEETH; the anterior teeth meaning those toward the front of the mouth and the posterior teeth meaning those toward the back of the mouth. The anterior teeth include the incisors and the cuspids, while the posterior teeth include the bicuspids and molars.

Another general classification divides the teeth into INCISING TEETH and MASTICATING TEETH, the incising teeth including the incisors and cuspids, and the masticating teeth including the bicuspids and molars.

SYSTEM OF NAMING AND NUMBERING THE TEETH

There are 32 teeth in the human mouth; 16 in the upper jaw which we call the maxilla, and 16 in the lower jaw which we call the mandible. The teeth are called incisors, cuspids, bicuspids and molars.

The MEDIAN LINE is an imaginary perpendicular line drawn through the center of the body, and divides the body into right and left halves.

Taking the right side for an example, and starting at the median line, the teeth are named as follows:

Upper right central incisor.
Upper right lateral incisor.
Upper right cuspid.
Upper right first bicuspid.
Upper right second bicuspid.
Upper right first molar.
Upper right second molar.
Upper right third molar.

Lower right central incisor.
Lower right lateral incisor.
Lower right cuspid.
Lower right first bicuspid.
Lower right second bicuspid.
Lower right first molar.
Lower right second molar.
Lower right third molar.

The left side is the same, except that the word left is substituted for right.

Several systems of numbering the teeth have been devised whereby it is much simpler to designate a tooth by number rather than by name. The system used in the army is as follows:

Beginning at the median line in the upper jaw and continuing backward, the teeth are numbered from 1 to 8; beginning at the median line in the lower jaw and continuing backward, the teeth are numbered from 9 to 16.

Thus, a number between 1 and 8 would indicate that a tooth was an upper, whereas a number from 9 to 16 would indicate that the tooth was a lower. The letter R or L is placed in front of the number to designate whether the tooth is in the right or left side of the jaw.

The following diagram may make this clearer:

MEDIAN LINE

Right								Left							
8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
16	15	14	13	12	11	10	9	9	10	11	12	13	14	15	16

In this system when we see a tooth designated as L3 we know that the upper left cuspid is meant. R9 would be the lower right central incisor, R14 the lower right first molar, etc.

SURFACES OF THE TEETH

Each tooth has five surfaces which can roughly be compared to the four sides and top of a box. Each side has a name by which we designate the various surfaces.

The MESIAL SURFACE is the surface or side of the tooth nearest the median line.

The DISTAL SURFACE is the surface or side of the tooth farthest from the median line.

The BUCCAL SURFACE is the outside surface of the tooth, or the side which lies next to the cheek. The term, buccal surface, is usually applied to the bicuspids and molars.

The LABIAL SURFACE is the outside surface of the tooth, or the side which lies next to the lips. The term, labial surface, is usually applied to the incisors and cuspids. The labial surface of the incisors and cuspids refers to the same side that we call the buccal surface in the case of the bicuspids and molars.

The FACIAL SURFACE is a term used to designate the side of the tooth next to the lips or cheeks, and can be applied to either the anterior or posterior teeth. The terms, labial, buccal and facial all refer to the same surface of the teeth.

The LINGUAL SURFACE is the inner surface of the teeth, or the side which lies next to the tongue.

The INCISAL SURFACE or INCISAL EDGE is the cutting edge of the tooth, and is used when speaking of this surface in the incisors and cuspids.

The OCCLUSAL SURFACE is the top surface or grinding surface, and is used when referring to this surface of the bicuspids and molars.

The entire name of the surface is ordinarily not used. Abbreviations which consist of the first letter of the word are generally used. M means mesial, D means distal, O means occlusal, etc.

Combinations of these letters are used to designate more than one surface. For instance, if we are speaking of an inlay that extends over both the mesial and occlusal surfaces of a tooth, we say that it is an MO inlay. Many combinations are used, such as DO, LO, MI, MOD, etc.

For descriptive purposes, the crown of a tooth is divided into thirds. The third nearest the incisal edge in the case of the incising teeth, or the occlusal surface in the case of the masticating teeth is called the incisal third or occlusal third as the case may be. The next third is called the middle third, and the third next to the gum is called the gingival third.

ROOTS OF THE TEETH

As dental technicians we are not as much concerned with the roots of the teeth as we are with the crowns. However, a brief description of them will be given.

The central incisors, lateral incisors, and cuspids, in both the upper and lower jaws are all single rooted teeth. The upper cuspids have the longest and heaviest roots of any of the teeth. The lower central incisors have the shortest and smallest roots.

The upper first bicuspids usually have two frail roots, one placed bucally and the other lingually. It is not uncommon for the two roots to be fused together giving the appearance of one single root. The upper second bicuspids are nearly always single rooted.

The upper first molar has three roots, two on the buccal and one on the lingual.

The upper second molar generally has three roots, and is quite similar to the first molar, except that there is more tendency for the roots to be fused together.

The upper third molar may have from 1 to 5 roots or even more. Often, three roots in this tooth will be fused together so as to form one big cone-shaped root. At other times there will be three or four small frail roots. The upper third molar and lower third molar are subject to far greater variation than any of the other teeth.

The lower bicuspids, both first and second, are single rooted.

The lower first molar has two roots, one mesial and one distal.

The lower second molar is similar to the first, except that we find more tendency for the roots to fuse together.

The lower third molar, like the upper third molar, is subject to great variation. Two roots are probably as commonly found as any other number, although very often there is only one, or there may be three or four.

DEFINITIONS

Unless you have had considerable previous training, there will be many terms which you will probably find confusing, or meaningless, but which you must know, because you will be confronted with them as long as you have any connection with dentistry. Definitions of the more important of these follow:

ALVEOLUS- The cavity, or socket, in the process of the maxillary bone in which the root of a tooth is embedded or fixed.

ALVEOLAR PROCESS - The projection of the maxillary bones which envelops the roots of the teeth and forms their alveoli.

APEX - The terminal end of the root of a tooth.

APICAL FORAMEN - The minute opening of the pulp canal at the apex of the root of a tooth.

AXIAL SURFACES - Those surfaces of the teeth that are parallel with their long axes. They are labial, buccal, lingual, mesial and distal.

BELL-CROWNED - A tooth in which the mesio-distal diameter of the crown is much greater than that of the neck.

CEMENTUM - A tissue resembling bone which forms the outer surface of the roots of the teeth.

CONTACT POINT - The point on the proximal surface of a tooth which touches a neighboring tooth.

CROWN - That portion of a tooth which is covered with enamel, and which projects from the tissues in which the root is fixed.

CUTTING EDGE - The edge formed by the junction of the labial and lingual surfaces of the incisor and cuspid teeth. In the cuspids the edge is raised to a point near its center.

CUSP - A pronounced elevation or point on the surface of a tooth, more especially on the occlusal surface.

DECIDUOUS TEETH - The teeth of the child which are shed to give place to the permanent teeth. They are sometimes referred to as temporary teeth, baby teeth, milk teeth, etc.

DENTINE - The hard tissue of which the main body of a tooth is formed.

DEVELOPMENTAL GROOVES - Fine depressed lines in the enamel of a tooth which mark the junction of its lobes. A tooth calcifies, or forms, from several centers. The lobes formed from these centers join to form the whole tooth, and the developmental grooves mark the joining of these lobes. These lines are not faults, but are normal markings, whereas fissures are faults caused by an imperfect joining of the lobes.

EMBRASURE - An opening that widens outward or inward. That portion of the inter-proximal space that widens toward the buccal or toward the lingual.

ENAMEL - A very hard tissue covering the crown of a tooth.

FISSURE- A fault in the surface of a tooth caused by the imperfect joining of the enamel of the different lobes. Fissures occur along the lines of the developmental grooves.

FOSSA - A round or angular depression in the surface of a tooth. These occur mostly in the occlusal surfaces of the molars, and in the lingual surfaces of the incisors.

GINGIVA - The portion of gum tissue enveloping the necks of the teeth crown-wise from the attachment at the gingival line. A shorter definition is the free margin of the gum.

GINGIVAL LINE - The line around the neck of a tooth at which the gingiva is attached. The line of junction of the enamel and cementum.

GROOVE - A long-shaped depression in the surface of a tooth.

INCLINATION - The inclination of a tooth is the deviation of the long axis of the tooth from the perpendicular.

INTER-PROXIMAL SPACE - The V-shaped space between adjoining teeth. This space is formed by the proximal surfaces of the adjoining teeth and the border of the alveolar process between the necks of the teeth. Normally this space is filled with gum tissue.

INTER-PROXIMAL EMBRASURE - That portion of the inter-proximal space which widens toward the lip or cheek, or toward the tongue.

MARGINAL RIDGE - The ridges, or elevations of enamel on the margins of the occlusal surfaces of the bicuspids and molars, and on the mesial and distal margins of the lingual surfaces of the incisors and cuspids.

MEDIAN LINE - An imaginary perpendicular line drawn through the center of the body, which divides the body into right and left halves.

NECK - That portion of the tooth which forms the junction of the crown and root.

OBLIQUE RIDGE - A ridge running obliquely across the occlusal surface of the upper molars. It is formed by the union of the triangular ridge of the disto-buccal cusp with the distal portion of the ridge forming the mesio-lingual cusp.

PIT - A sharp pointed depression in the enamel. Pits occur mostly where several developmental grooves join, as in the occlusal surfaces of the molars, and at the endings of the buccal grooves on the buccal surfaces of the molars.

PROXIMAL SURFACE - The surface of a tooth which lies next to another tooth. This nearly always means mesial or distal.

RIDGE - A long-shaped elevation on the surface of a tooth.

RUGAE - A series of irregular ridges in the roof of the mouth.

SEPTUM - That portion of the alveolar process which lies between the roots of the teeth separating their alveoli.

SULCUS - A notable long-shaped depression in the surface of a tooth, the inclines of which meets at an angle. A sulcus has a developmental groove at the junction of its inclines.

SUPPLEMENTAL GROOVE - A shallow long-shaped depression in the surface of a tooth, generally with a smoothly rounded bottom. Supplemental grooves differ from developmental grooves in that they do not mark the junction of lobes.

SUPPLEMENTAL LOBE - A lobe that does not belong to the typical form of the tooth; an additional lobe.

SUPPLEMENTAL RIDGE - A ridge on the surface of a tooth that does not belong to the typical form of the tooth; an additional ridge.

TRANSVERSE RIDGE - A ridge formed of two triangular ridges, which join to form a continuous ridge across the occlusal surface of a tooth.

TRIANGULAR RIDGE - A ridge running from the point of a cusp toward the central portion of the occlusal surface of a tooth.

TUBERCLE - A slight rounded elevation on the surface of a tooth. Tubercles occur frequently on the linguo-gingival ridge of the incisors, and occasionally upon various parts of other teeth. They are deviations from typical tooth forms.

Up to this point we have confined our study to the teeth only. However, there are other anatomical structures or features about the mouth and adjacent parts which are also of great importance, and which must be given due consideration in the construction of a denture.

Certain areas of the mouth are much harder than other areas, and we must make reliefs to compensate for this. There are certain areas over which excessive pressure is undesirable and must be avoided. We must know the various movements of the jaw, and we should know what causes these movements.

We could just tell you to relieve here or relieve there, but if you understand why these various reliefs are necessary, you will be able to do the work much more intelligently. We realize fully that you will have some difficulty with the subject we are about to take up, but it is our desire that you do your best in trying to grasp it. The subject of anatomy with its peculiar names is a difficult one at best, but we have simplified it for you as much as possible, and have cut out anything considered non-essential to you as dental technicians. These lectures will be supplemented by small group demonstrations at which we shall have skulls, models and pictures on which various structures and landmarks will be pointed out. There will also be several class discussions and it is our belief that you will be able to understand these things, and will be better technicians for having done so.

THE HARD PALATE AND THE SOFT PALATE

The hard palate is the roof of the mouth. It is formed by the union of the horizontal portions of the maxillary bones and palate bones at the median line. The front and side borders of the hard palate consist of that portion of the bone which gives support to the teeth. The posterior border is irregular and has attached to it a muscular like curtain which we call the soft palate. The hard palate is covered throughout by thick, firm, mucous membrane which is closely adherent to the bone.

In the center of the hard palate is a ridge or fold of mucous membrane, which follows the median line from before backward. This ridge is called the PALATAL RAPHE or MEDIAN RAPHE and indicates the line of union formed during the development of the parts. Near the center of the hard palate the raphe frequently separates into two smaller ridges which continue backward, side by side, thus making it appear wider here than toward the front or back. As it runs posteriorly the raphe usually diminishes in size, disappearing entirely as the soft palate is approached, although occasionally it is quite pronounced the entire length of the hard palate.

This ridge is usually much harder and less compressible than the mucous membrane on either side of it, and unless we relieve the denture over this hard area and allow it to rest evenly over the entire surface of the roof of the mouth, the denture will rock in the mouth using the raphe as a fulcrum. This condition not only causes the denture to be unsatisfactory as to fit, but also causes a soreness over the ridge, and a continued irritation of this kind over a period of time might even be the cause of a malignant growth.

On either side of this central ridge, or r aphe, in the anterior part of the mouth we find a number of fantastically arranged folds or wrinkles of mucous membrane which are called RUGAE. The number and size of these wrinkles vary considerably. In some cases they are quite numerous and very prominent, while in other cases they are few in number and only slightly developed.

At the anterior end of the r aphe and just behind the central incisors there is an opening in the bone which is called the ANTERIOR PALATAL FORAMEN through which certain nerves and blood vessels pass.

At the back part of the hard palate are two other openings in the bone which we call the POSTERIOR PALATAL FORAMINA. These are found on either side of the hard palate and are located about half way between the median line and the gingival border of the molars, and about 5 millimeters anterior to the junction of the hard and soft palate.

These openings and their positions are important to us because we often have to relieve over these areas in our dentures. As we have seen, nerves and blood vessels pass through them, and in some cases excessive pressure by the denture over these areas will cause a very uncomfortable burning sensation over the roof of the patient's mouth unless proper relief has been made.

The SOFT PALATE is attached to the posterior border of the hard palate, from which it is continued as a backward prolongation of its soft tissue. It runs downward and backward, and forms part of the posterior border of the oral cavity. The soft palate is composed of thin, dense, muscular fibers, blood vessels, nerves and mucous glands. It has no underlying bony support. In short, we might say that the hard palate was the part of the roof of the mouth with underlying bony support, whereas the soft palate was the part with no bony support. The soft palate is movable, but the hard palate is not. The posterior border of a denture should never end on the hard palate; it should always extend a short distance over onto the soft palate.

THE MANDIBLE

The mandible, or lower jaw bone, is the heaviest and strongest bone of the head. It supports the 16 lower teeth and serves as a frame-work for the floor of the mouth. It is movable, having no bony union with the skull proper. It is attached to the skull by movable joint called the temporo-mandibular articulation, which will be taken up in detail later on. The mandible is symmetrical in form and consists of a horizontal portion called the BODY, and two vertical portions each of which is called a RAMUS.

The mandible forms from two centers and consists of two identical halves which meet at the median line forming a slight vertical ridge which indicates the line of union of the two halves. This ridge or junction is called the SYMPHYSIS. Each half of the mandible has two surfaces, an inner and outer one, and on each surface are certain points or landmarks which we should recognize.

The EXTERNAL OBLIQUE LINE is a well defined ridge extending obliquely across the facial or outer surface of the mandible. It extends from the mental process upward and backward to the base of the vertical portion of the bone, and is continuous with the anterior border of the vertical portion or ramus.

The MENTAL FORAMEN is an opening in the bone usually situated about halfway between the upper and lower borders of the body of the mandible, and between the roots of the first and second bicuspid teeth. It gives passage to certain nerves and accompanying blood vessels. Ordinarily, because of its position, no pressure is exerted on this nerve by a denture, and no relief is necessary. However, in very old persons where teeth have been absent a long time, the bone has absorbed a great deal, and the foramen is found very close to the upper border of the body of the mandible. In these cases it sometimes becomes necessary to relieve the denture over this area to avoid excessive pressure with resulting pain.

The MYLOHYOID RIDGE or INTERNAL OBLIQUE RIDGE is a heavy ridge on the inner surface of the mandible, which occupies a position closely corresponding to the external oblique line on the facial surface. It begins near the base of the bone at the median line, and passes backward and upward, increasing in prominence until the base of the vertical portion of the bone is reached, into which it gradually disappears.

The INFERIOR DENTAL FORAMEN or MANDIBULAR FORAMEN is an opening in the bone located near the center of the inner surface of the ramus of the mandible. It is the entrance to the mandibular canal which passes downward and forward through the ramus and body of the mandible finding an exit at the mental foramen on the external surface of the mandible.

The MYLOHYOID GROOVE is a depression or groove found on the inner surface of the mandible. It starts at the base of the mandibular foramen and runs obliquely downward and forward below the mylohyoid or internal oblique ridge. It accommodates the nerves and blood vessels which supply the floor of the mouth,

The SIGMOID NOTCH is the crescent shaped upper border of the ramus of the mandible.

The anterior portion of the notch is formed by a flattened cone-shaped projection called the CORONOID PROCESS which serves as an attachment for one of the muscles of mastication.

The posterior portion of the notch is formed by a rounded or oblong projection which is called the CONDYLOID PROCESS. The condyloid process, or condyle, is the portion of the mandible that enters into the formation of the joint which we refer to as the TEMPORO-MANDIBULAR ARTICULATION. The condyle is divided into a head which is the rounded upper portion of the process, and the neck which is the somewhat constricted portion that joins the head to the main body of the ramus.

THE TEMPORO-MANDIBULAR ARTICULATION

Attention has already been called to the fact that the mandible has no bony union with the skull proper, but is attached to it by a movable joint. It is this joint or attachment that we speak of as the temporo-mandibular articulation. It receives its name from the two bones which enter into its formation, the temporal bone and the mandible.

This joint is the seat of motion in the mandible, and entering into its construction are bones, ligaments, cartilage, and synovial membrane, these being the tissues essential to all movable articulations. The various movable joints of the body are classified according to the nature of the movement, and correspond to the mechanical actions known as hinge joint, ball and socket joint, gliding joint, pulley joint, etc. The temporo-mandibular joint, is a combination of the gliding movement and hinge movement.

The bony parts entering into the formation of this joint are the glenoid fossa of the temporal bone and the condyloid process of the mandible. The GLENOID FOSSA is a rounded cavity or depression, in the temporal bone, into which the head of the condyle fits to form the joint.

The movement of the jaw is not limited to a simple opening and closing motion. The jaw is protruded (pushed forward), or retruded (pushed backward). There are also lateral movements in which the mandible is moved to either side. All of these various movements and the function of the teeth are closely associated with the temporo-mandibular articulation, and for this reason it is important that we understand how it is constructed. The articulators which we use are made so that more or less normal movements of the mandible can be reproduced, the metal parts which form the joint of the articulator being similar to the bony parts forming the temporo-mandibular articulation.

There is a wide variation in this joint in various individuals, and in many cases the same person will have considerable variation between the joint on his right side and left side.

In non-adjustable articulators an average joint has been built into the articulator which fits most cases fairly well. Cases which vary greatly from the average or cases in which there is considerable difference in the right and left temporo-mandibular articulations will not be as satisfactory when built on the non-adjustable type of articulator, as when they are constructed on an adjustable type.

Adjustable articulators are so constructed that the angles of the joints of the articulator can be varied and set to exactly reproduce the angles of the temporo-mandibular articulation of the patient. Group demonstrations will be given in which we will compare the temporo-mandibular articulation in a skull with the temporo-mandibular articulation as it is reproduced in the articulator.

THE MUSCLES OF MASTICATION

Occupying the back part of the side of the face, and forming an independent group, are four muscles which are usually classed as the muscles of mastication. While this is true to a great degree, they are not the only muscles brought into action during this process. However, these four are the only ones we shall consider.
They are:

1. The Masseter muscle.
2. The Temporal muscle.
3. The Internal Pterygoid muscle.
4. The External Pterygoid muscle.

Each one will be taken up separately. As stated previously, you will no doubt have some difficulty with the anatomical terms used, but in the group demonstrations everything will be pointed out to you on a skull, and it is hoped that you will learn where the muscles are attached and what their general action is, even though you cannot give the origin and insertion of each muscle by its proper name.

Generally speaking, the masseter, temporal, and internal pterygoid elevate or close the lower jaw, the principle function of the external pterygoid being to extend the lower jaw so that the lower teeth pass beyond the upper. The muscles which depress the jaw are certain muscles of the neck which we shall not consider.

1. The Masseter Muscle.

This muscle extends generally from the zygomatic arch and the lower border of the malar bone, downward and backward to the outer surface of the ramus of the mandible.

It is a strong, heavy muscle whose main action is to draw slightly forward and close the jaw.

2. The Temporal Muscle.

This is a large, fan-shaped muscle whose broad end is attached to the entire surface of the temporal fossa. From here it extends downward passing underneath the zygomatic arch, and is attached at its narrow end to the coronoid process of the mandible.

Its action is to close the lower jaw, some of its fibers drawing the jaw backward after certain other muscles have protruded it.

3. The Internal Pterygoid Muscle.

The internal pterygoid is attached at one end to the inner surface of the external pterygoid plate, the tuberosity of the palate bone and a small portion of the maxilla. From here it extends downward, backward and outward, its other end being attached to the internal surface of the ramus of the mandible at its lower and posterior borders.

It is a thick, sheet-like muscle whose action is to close the jaw and at the same time draw it backward and throw it toward the opposite side.

4. The External Pterygoid Muscle.

The external pterygoid is composed of two distinct heads, and upper and a lower. The upper head arises from the greater wing of the sphenoid bone and from the internal pterygoid ridge, and is inserted into the inter-articular cartilage, into the capsule of the joint, and into the neck of the condyle. The lower head arises from the outer surface of the external pterygoid plate and is inserted into the neck of the condyle.

The action of this muscle is to draw the condyle and inter-articular cartilage forward and inward, the combination of these two movements producing an oblique movement of the lower molars with respect to the opposing upper molars.

THE FRENA OF THE MOUTH

In various situations about the labial, buccal, and lingual surfaces of the gums, small slender folds of mucous membrane are found extending into the surrounding tissues. These folds, which act as a bridle or curb to the adjacent movable parts, are known as the FRENA OF THE MOUTH.

The principle frena are found at the median line and are three in number, named as follows:

1. Frenum Labium Superioris.
2. Frenum Labium Inferioris.
3. Frenum Linguae.

The Frenum Labium Superioris extends from the inner surface of the upper lip to the upper gum, and limits to some extent the movement of the upper lip. Its attachment to the gum is quite variable, sometimes being attached very high, and in other cases extending down to the gingival border of the teeth. The Frenum Labium Superioris is usually much larger than the Frenum Labium Inferioris.

The Frenum Labium Inferioris extends from the inner surface of the lower lip to the lower gum, and limits to some extent the movement of the lower lip. As in the upper the attachment to the gum is variable. This frenum is the smallest of the three principle frena and in some cases is so small that it cannot be seen unless the lip is stretched.

The Frenum Linguae extends from the under surface of the tip of the tongue to the lingual surface of the lower gums of the median line. This frenum limits the movement of the tongue to some extent and is the largest and strongest of the three principle frena. It is much stronger than those connected with the lips.

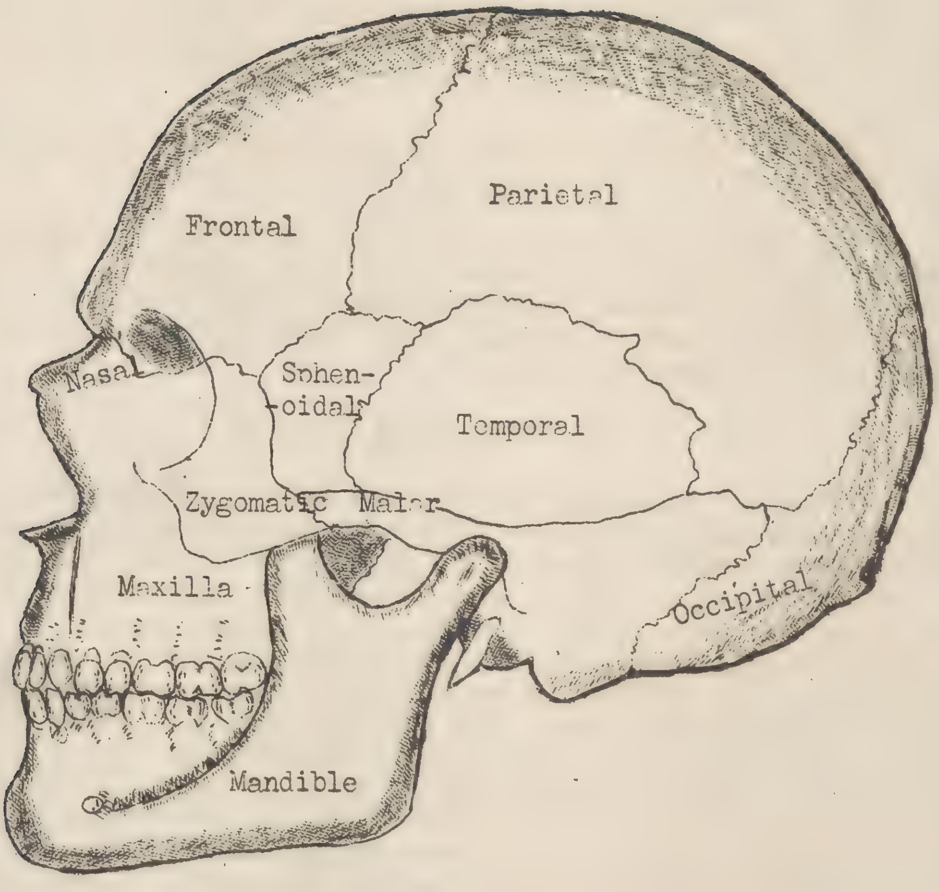
Similar bridles are found in the buccal region, usually near the bicuspid teeth, but they are much smaller than those at the median line.

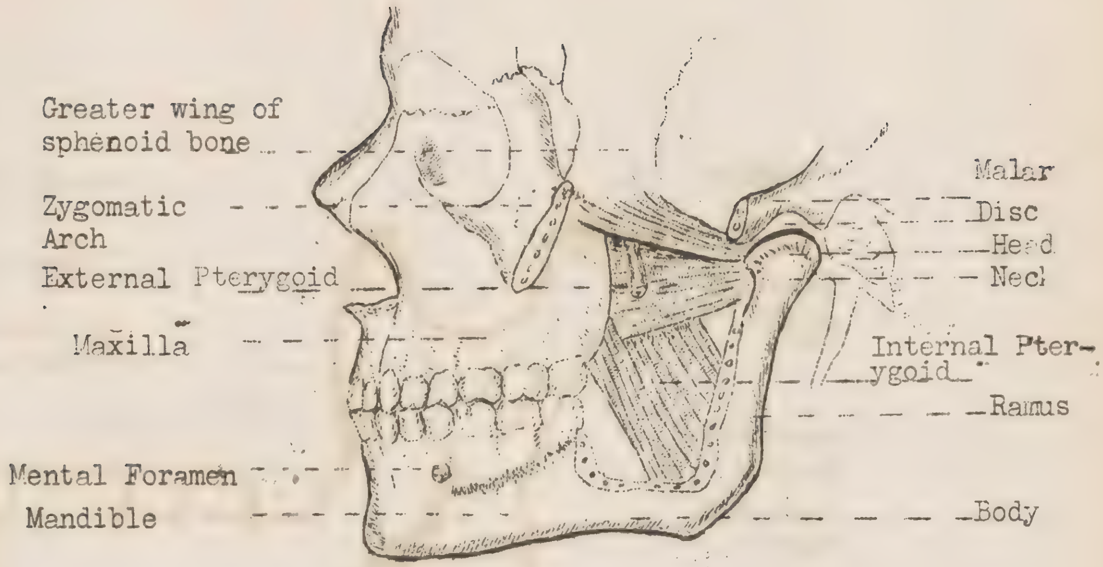
The frena are of great importance to us because allowance must be made for them in the dentures which we construct. If a denture is constructed without the proper allowance having been made for the frena, it will be a matter of only a few hours until they are so sore that the denture cannot be worn.

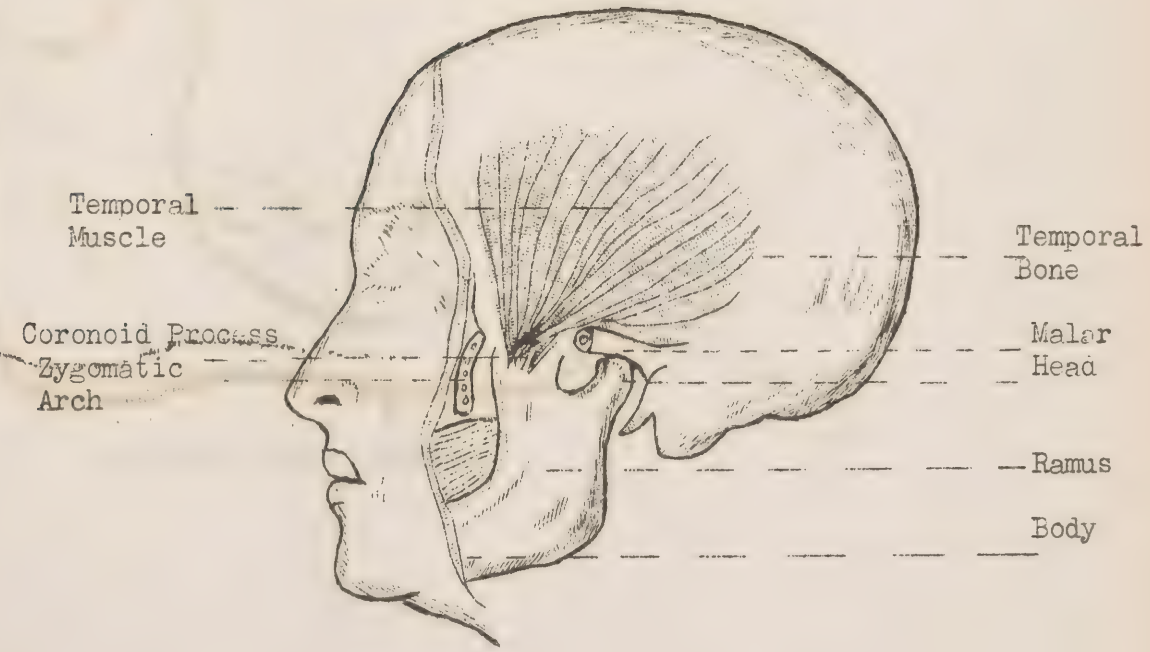
TORUS PALATINUS

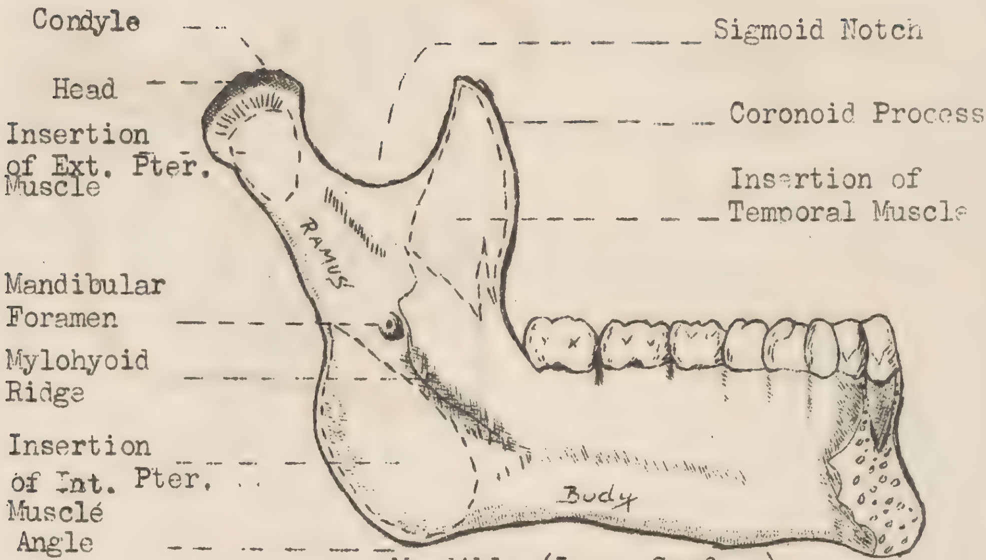
This is a condition that we are occasionally confronted with in making dentures. It consists of a bony protuberance covered with mucous membrane usually found in the roof of the mouth. The protuberance varies greatly in size, some being quite small, while others are so large that they almost fill the vault of the mouth. In most cases they should probably be removed surgically, but for one reason or another they are frequently not removed, and we are called on to construct dentures over them. They are hard like the median raphe and good relief must always be made over them for the same reasons that we relieve over the median raphe. These reasons you will remember were (1) to permit of a more perfect fit by eliminating rocking of the denture, and (2) to avoid soreness over these areas and eliminate the possibility of malignant growths developing due to long continued irritation.

This condition is occasionally found in other locations about the mouth. Probably the next most common place being on the lingual surface of the mandible in the region of the cuspids and bicuspids.

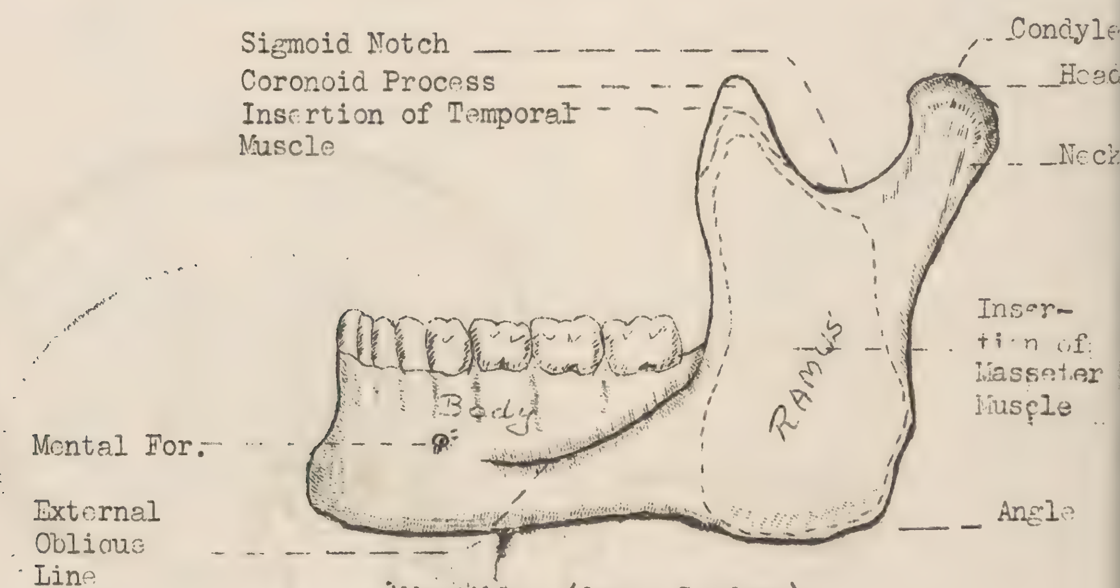

Parietal
Frontal
Nasal
Sphen-
-oidal
Temporal
Zygomatic
Malar
Maxilla
Occipital
Mandible


Greater wing of sphenoid bone
Zygomatic Arch
External Pterygoid
Maxilla
Mental Foramen
Mandible
Malar
Disc
Head
Neck
Internal Pterygoid
Ramus
Body

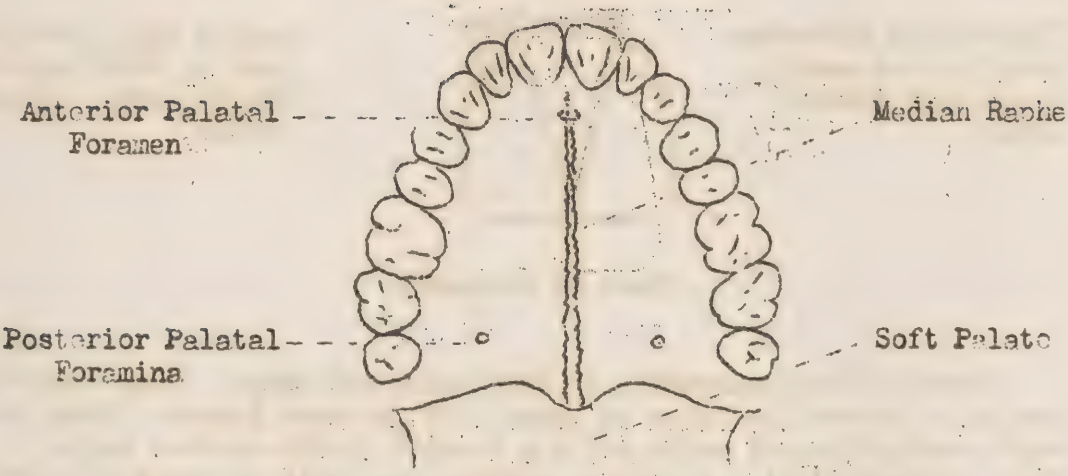

Temporal Muscle
Coronoid Process
Zygomatic Arch
Temporal Bone
Malar
Head
Ramus
Body



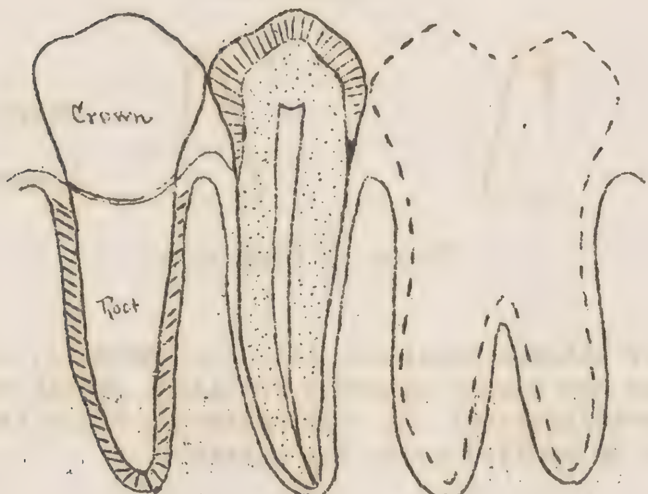
Mandible (Inner Surface)



Mandible (Outer Surface)



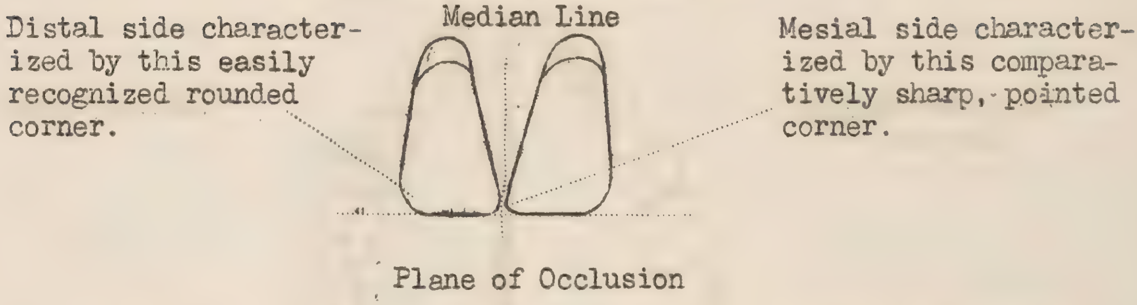
Anterior Palatal Foramen
Median Raphe
Posterior Palatal Foramina
Soft Palate



Crown
Root

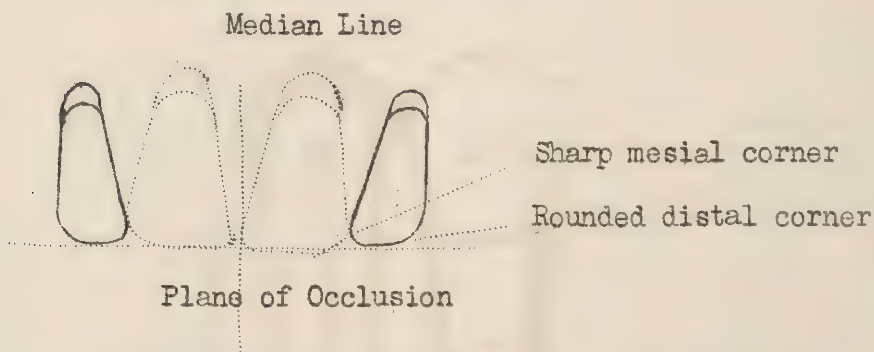
IDENTIFICATION OF TEETH

UPPER CENTRAL INCISORS



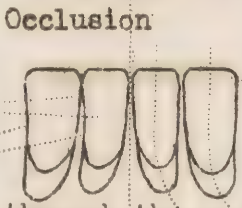
Readily distinguishable by their size and shape. They resemble the upper lateral incisors in shape, but are much larger. Note the acute mesial-incisal angle and the rounded distal-incisal angle. These characteristics determine whether the tooth is right or left.

UPPER LATERAL INCISORS



The upper lateral incisors, like the centrals, once their general character has become somewhat familiar, should cause no difficulty in identification. In distinguishing right from left the same rule can be applied as to the centrals.

LOWER CENTRAL AND LATERAL INCISORS



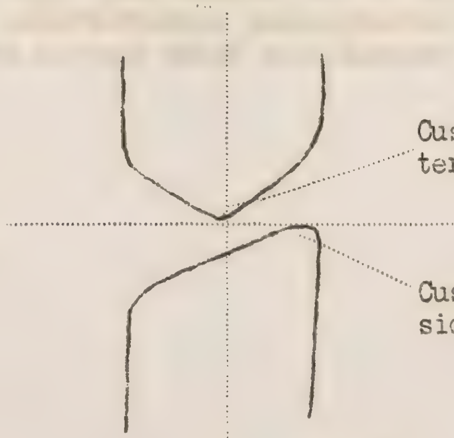
The lower centrals and laterals resemble each other very closely. However, the centrals are slightly smaller, and, the distal-incisal corner of the laterals is rounded to a noticeably greater degree than that of the centrals. Right and left may be determined by noting the curve of the tooth axis.

Another means of telling right from left, this also being true of the lower cuspids, is by looking at the surface of the tooth in which the pin is set and noting the slightly raised ridge. This ridge is always on the mesial side of the tooth.

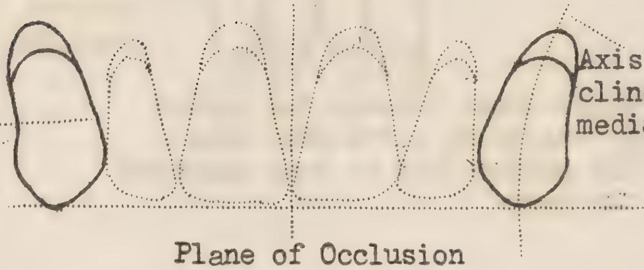
UPPER AND LOWER CUSPIDS

In contrast to the upper and lower centrals and laterals, whose incisal edges parallel the occlusal plane, those of the upper and lower cuspids contact the occlusal plane only with the apex of their prominent incisal cusp.

An upper cuspid may be distinguished from a lower by noting the position of the cusp on the incisal surface, as follows:

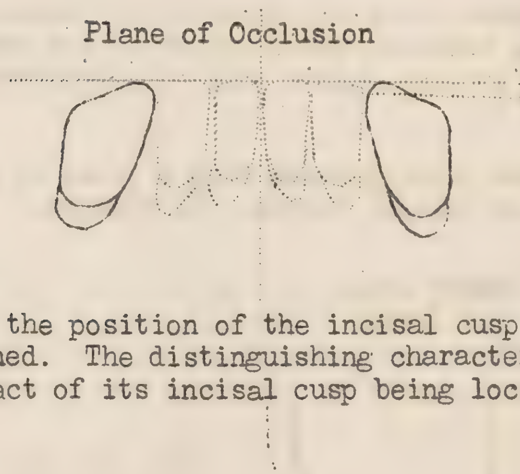


UPPER CUSPIDS



General shape of the tooth gives it the appearance of curving away from the median line as the neck of the tooth is approached, thus distinguishing right from left. The distinguishing characteristic of this tooth is the fact of its incisal cusp being located on the center line.

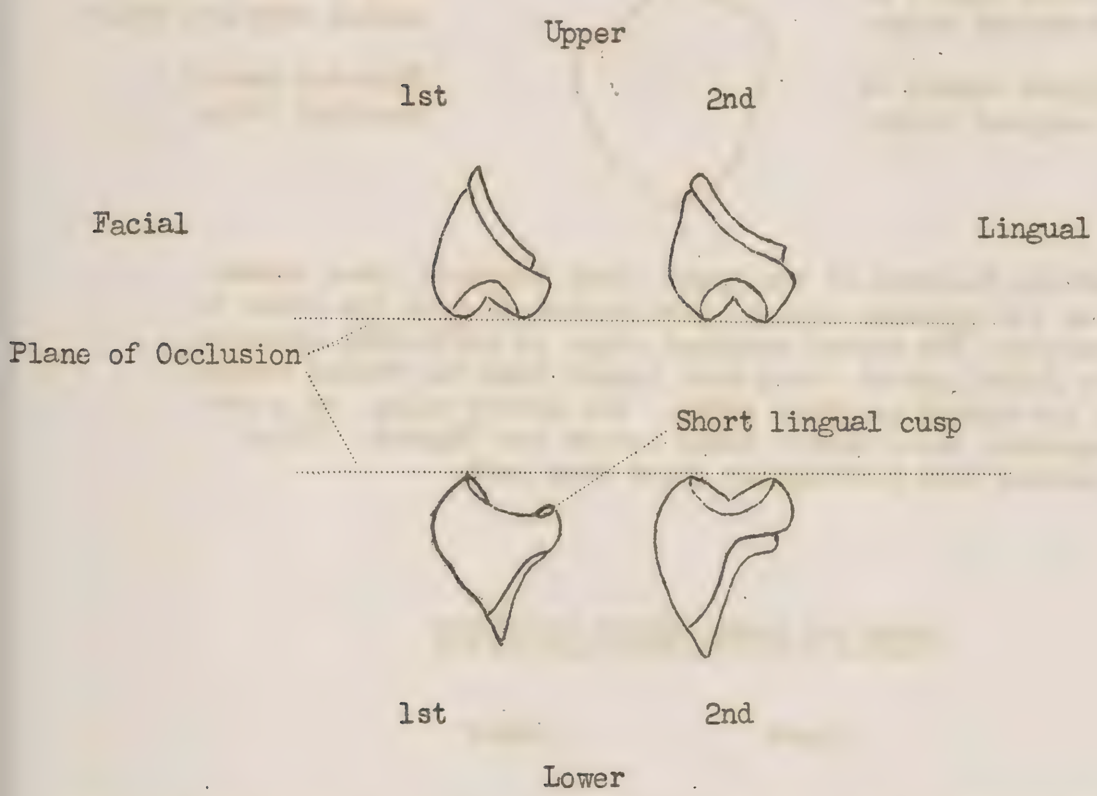
LOWER CUSPIDS



By noting the position of the incisal cusp right and left can be determined. The distinguishing characteristic of this tooth is the fact of its incisal cusp being located at the mesial side.

BICUSPIDS

Side view of the four bicuspids

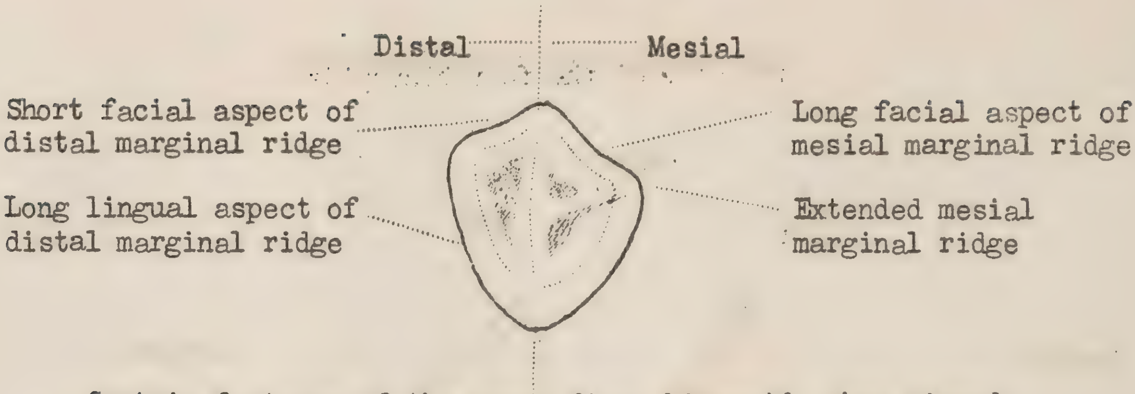


The characteristic feature of the bicuspids is that they have two prominent cusps, one on the facial side and one on the lingual.

LOWER FIRST BICUSPIDS

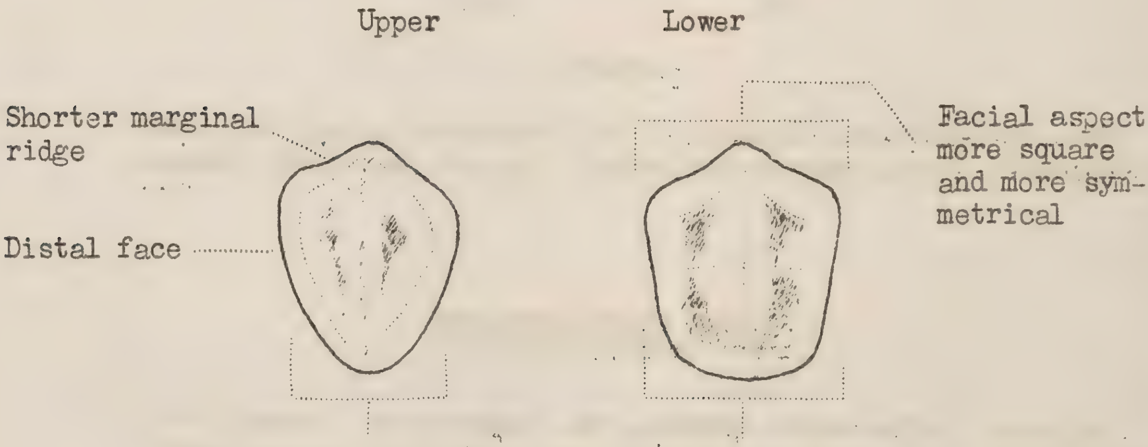
As shown in the above drawing, the lower first bicuspid has a short lingual cusp, only the facial cusp contacting the occlusal plane. This characteristic identifies this tooth immediately.

UPPER FIRST BICUSPIDS



Certain features of the upper first bicuspid, when viewed from the occlusal aspect, distinguish it from the other bicuspids. The mesial marginal ridge is noticeably extended, its facial aspect being much longer than the facial aspect of the distal marginal ridge. The latter ridge, as a consequence, has a longer sweep toward the lingual. These features also distinguish right from left.

UPPER AND LOWER SECOND BICUSPIDS



Lingual aspect of upper more oval-shaped. The lower tends toward squareness.

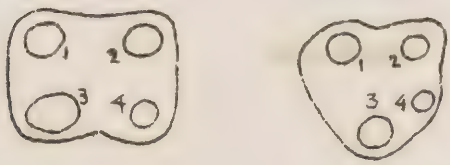
The shorter facial aspect of the distal marginal ridge of the upper bicuspid furnishes a clue as to right and left. The anatomical features of the lower bicuspid furnish no clues as to whether it is right or left.

MOLARS

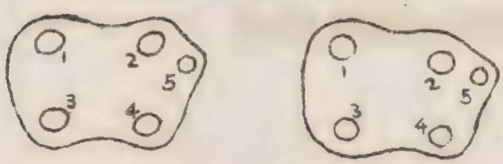
In distinguishing between upper and lower molars, one unmistakable rule can be relied upon, that is, that the upper molars have four cusps and the lowers five. This can be best shown by representing the teeth diagrammatically, the small circles representing the cusps:

Upper

1st 2nd



Four Cusps



Five Cusps

1st 2nd

Lower

UPPER FIRST MOLAR

Facial

Mesial

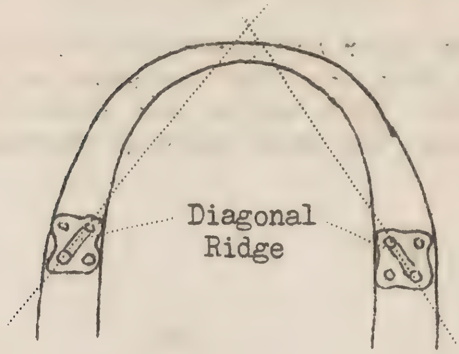
Diagonal Ridge

Distal

Distal-Lingual Groove

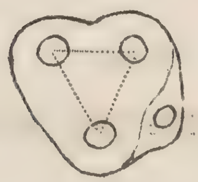
Lingual

The upper first molar is approximately square. It has a diagonal ridge running from the mesial-lingual cusp to the distal-facial cusp. Adjacent to this ridge, and distal to it, is a prominent groove, called the distal-lingual groove. By noting the direction of the diagonal ridge, it can be immediately determined whether the tooth is right or left, because an imaginary line projected through the ridge and extended will pass through the front-center of the mouth, as follows:



Upper Jaw

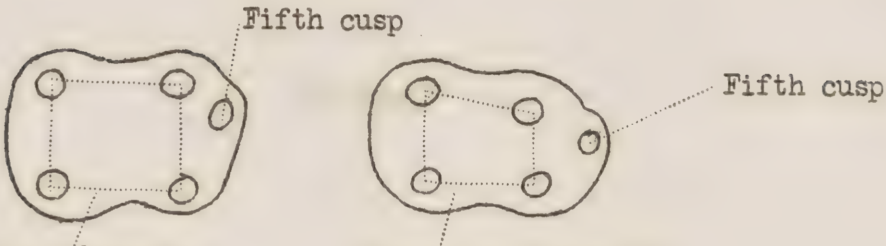
UPPER SECOND MOLAR



The general shape of this tooth may be thought of as triangular with, however, a bulge on one side - the distal - where the fourth and smallest cusp is located. This fourth cusp immediately affords a clue as to whether the tooth is right or left.

LOWER FIRST AND SECOND MOLARS

1st 2nd



Oblong character of first molar

Irregular figure of second molar, due to narrowing at the distal end.

In contradistinction to the upper molars, both the first and second lower molars are oblong in their general shape. The lower second molar, however, narrows toward the distal end. This characteristic immediately differentiates it from the first molar. Imaginary lines connecting the cusps of these two teeth illustrate this feature. The fact that the fifth cusp is on the distal face of the tooth indicates immediately whether the tooth is right or left.

POSTERIORS

On the under side of all posterior teeth are raised dots. These dots indicate whether a tooth is a first or a second molar or bicuspid, and whether the tooth is right or left. A first molar or bicuspid has only one dot, a second two. The dots are always located on the mesial side of the tooth, thus indicating right and left. The dots, however, do not indicate upper and lower; consequently, to determine whether a tooth is upper or lower, a knowledge of the anatomy of the teeth must be relied upon.

PART III

LABORATORY TECHNIQUE

CHAPTER I

Tooth Carving:

The first laboratory work that will be taken up in this course will be the carving of five teeth; the upper central, upper cuspid, upper first bicuspid, upper first molar, and lower first molar. These teeth are most typical of the various characteristics of all teeth found in the human jaw.

The reason for the carving technic is to acquaint you with the following:

1. The use of various instruments and materials such as the Boley gauge wax carver, and carving wax.
2. To acquire a knowledge of the tooth form and occlusal patterns of teeth so that you will be able to reproduce them in crown and bridge work.
3. To help segregate the porcelain teeth that are used in denture construction into their proper classification.

A Boley gauge, a small blade, a wax carver, and a piece of carving wax are the only necessary instruments. The Boley gauge consists of a fixed rule divided into centimeters and millimeters with a small slide rule having ten markings, each one of which is 1/10 of a millimeter less than a millimeter. The reading of the distance measured is found on the fixed rule opposite the first marking on the slide rule. A small catch on the slide rule locks the slide with the desired measurement.

The measurements used are found in our Morphology charts. They represent a geometric form by which a tooth is formed. The dimensions to be used are:

1. Greatest length of crown on the buccal surface.
2. Mesial - Distal diameter of the crown.
3. Greatest labial (buccal) and lingual diameter of the crown.

The dimensions are further divided into blocked and finished dimensions. The blocking dimensions are 2 millimeters larger than the finished dimensions. We are to carve our teeth twice the given dimensions. These dimensions are an average derived from measuring a great many natural teeth.

Steps in Carving:

1. Draw a line 2mm. below the top of wax.
2. Mark the surfaces of tooth (lingual, labial, mesial, distal, etc.) on the lower half of the block.
3. Measure the height of the crown on the labial using the Boley gauge and transfer this dimension to the block using the top marking as a guide.

4. Divide the block in half vertically by scratching a fine line from the top to the bottom of the block.

5. Measure the mesio-distal width of the crown so that tooth will be in center of the block using half of the dimension on each side of the middle line.

6. Divide the crown into horizontal thirds (incisal, middle, and gingival).

7. Using the diagram of the tooth in our text as a guide we then outline the blocked form accordingly.

8. Carefully cut away the surface on both the mesial and distal sides.

9. Re-divide the mesial surface using labial-lingual diameter, divide into horizontal thirds, outline the tooth form and cut away the excess.

10. The tooth is then shaped to conform to the finished dimensions and to the shape of the model.

11. The lingual or occlusal pattern is then carved out.

12. Polish the tooth by rubbing it lightly with a cloth. Soap and water may be used to attain a high polish.

Morphology of the Tooth

Upper	Central	Lateral	Cuspid	1st Bicuspid	2nd Bicuspid	1st Molar	2nd Molar
Length over all	22.5	22.0	26.5	20.6	21.5	20.8	20.
Greatest length of crown on Labial-Buccal	10.0	8.8	9.5	8.2	7.5	7.7	7.2
Greatest length of crown - lingual	10.5	8.9	9.5	6.6	7.0	7.7	7.2
Greatest mesio-distal diameter of crown	9.0	6.4	7.6	7.2	6.8	10.7	10.4
Greatest labial-buccal and lingual diameter of crown	7.0	6.0	8.0	9.1	8.8	11.8	11.5
Mesio-distal diameter at cervix	6.3	4.4	5.2	4.9	5.3	7.5	6.7
Labio-lingual diameter at cervix	6.1	5.4	7.6	8.0	7.0	10.3	10.0

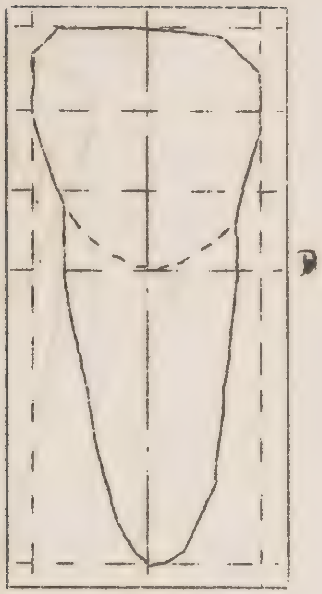
These are the finished average dimensions.

Morphology of the Tooth

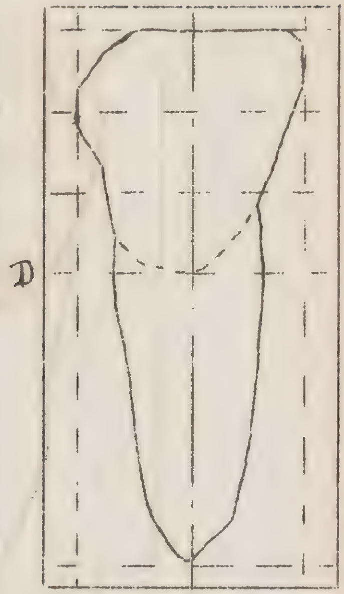
Lower.	Central	Lateral	Cuspid	1st Bicuspid	2nd Bicuspid	1st Molar	2nd Molar
Length over all	20.7	21.1	25.6	21.8	22.3	21.7	21.5
Greatest length of crown on Labial-Buccal	8.8	9.6	10.3	7.8	7.9	8.5	8.5
Greatest length of crown - lingual	8.8	10.1	10.8	5.6	7.5	7.0	7.0
Greatest mesio-distal diameter of crown	5.4	5.9	6.9	6.9	7.1	10.7	10.2
Greatest labial-buccal and lingual diameter of crown	6.0	6.4	7.9	7.7	8.0	10.0	9.8
Mesio-distal diameter at cervix	3.5	3.8	5.2	4.7	4.8	8.8	8.4
Labio-lingual diameter at cervix	5.3	5.5	7.5	6.3	6.6	8.5	8.3

These are the finished average dimensions.

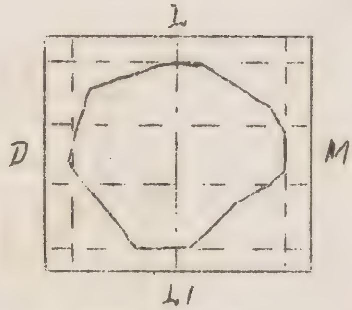
Upper Right Central



Labial

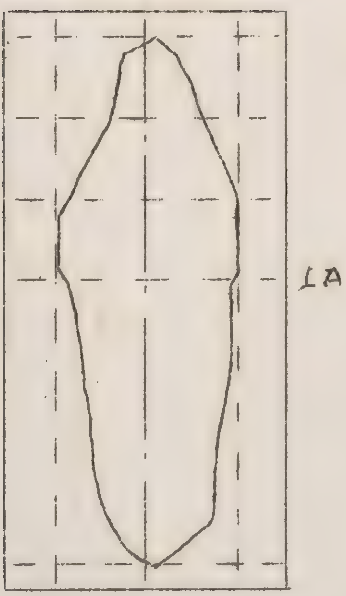


Lingual

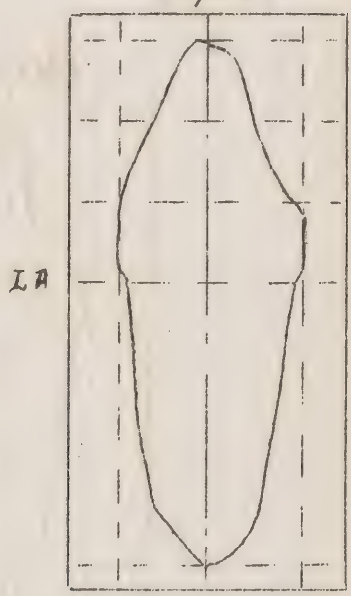


Occlusal

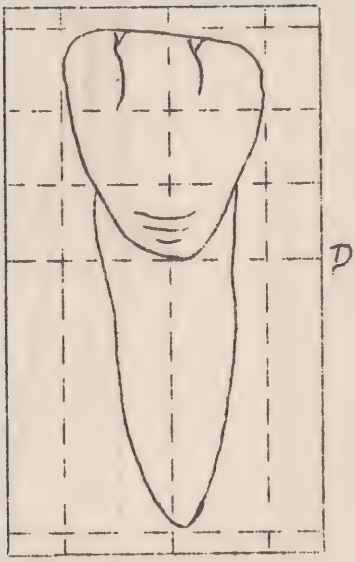
Mesial



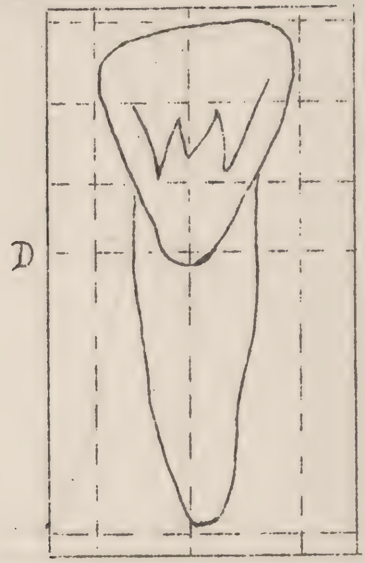
Distal



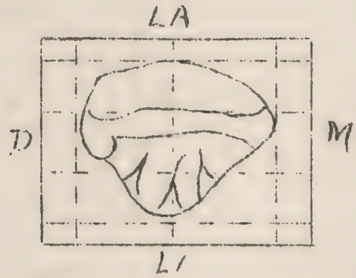
Upper Right Central.



Labial

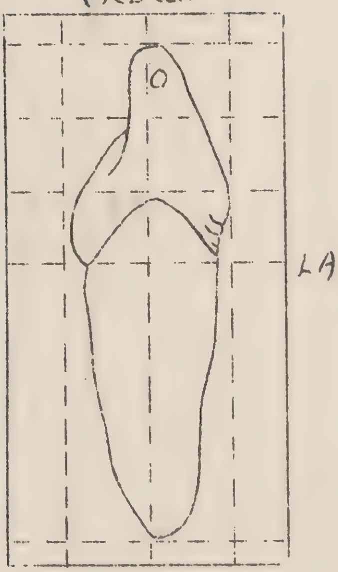


Lingual

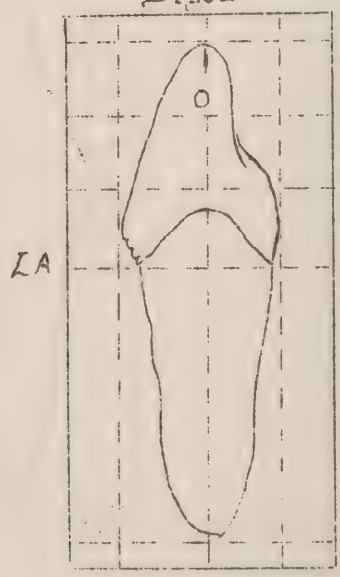


Occlusal

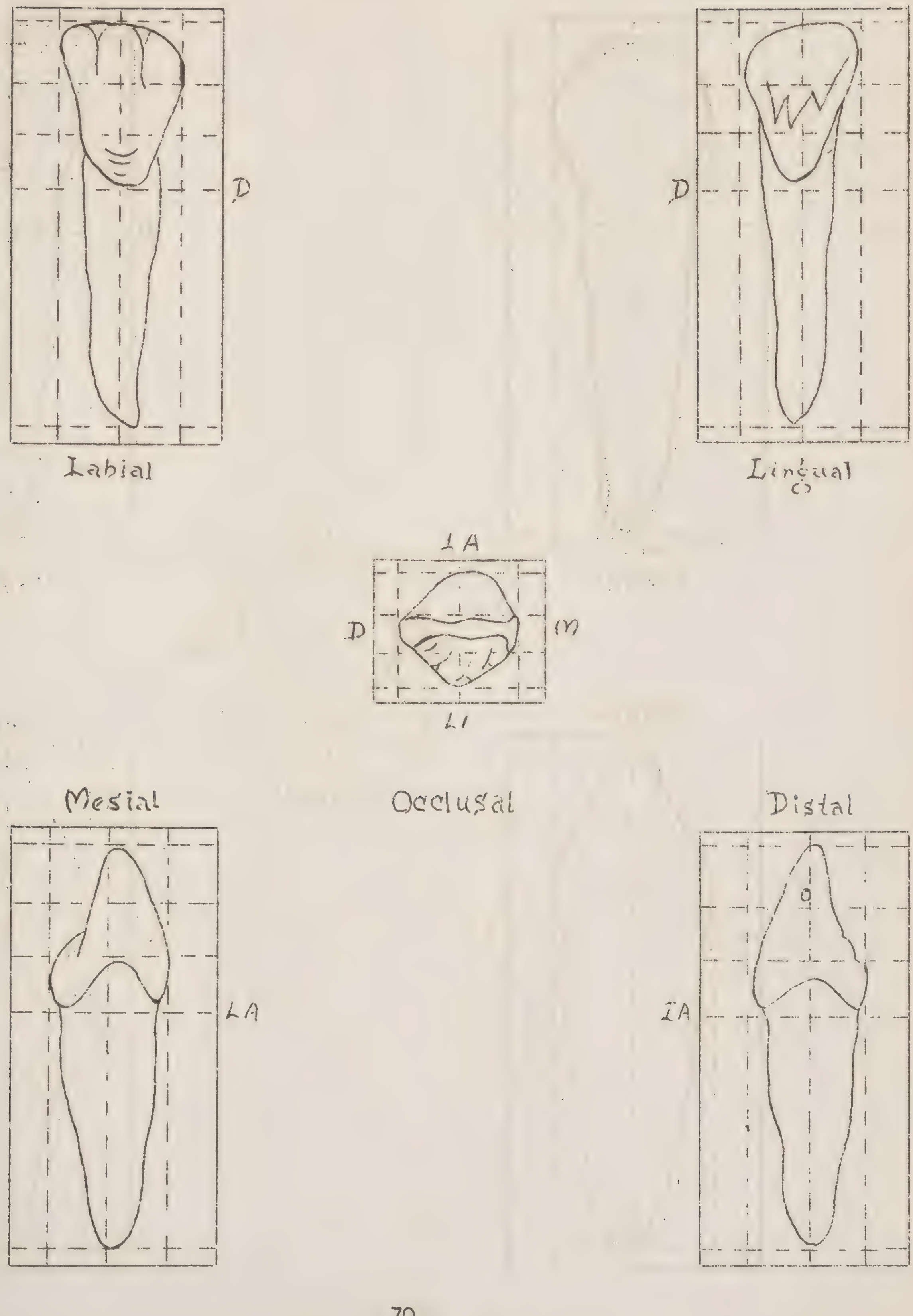
Mesial



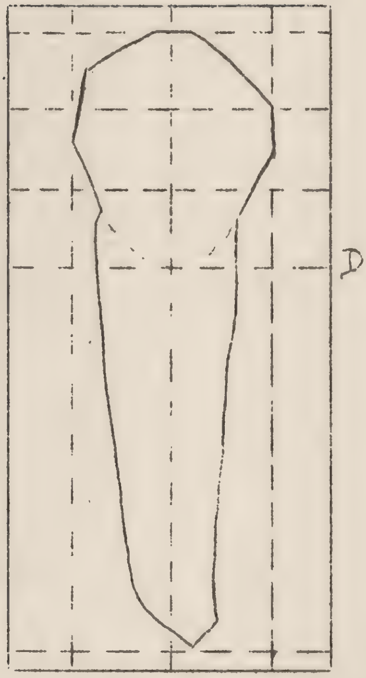
Distal



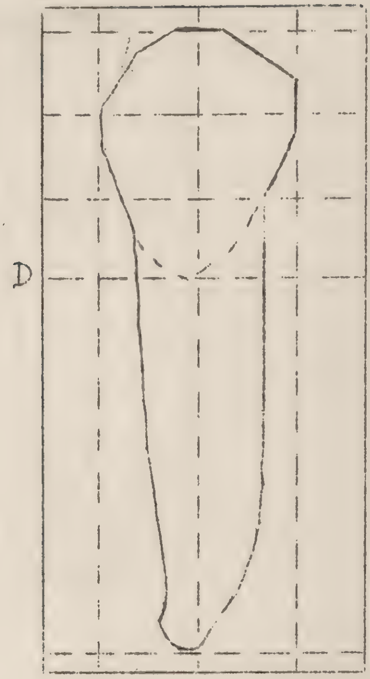
Upper Right Lateral



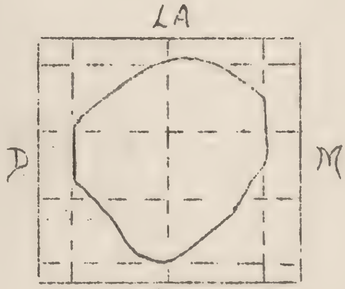
Upper Right Cuspid



Labial

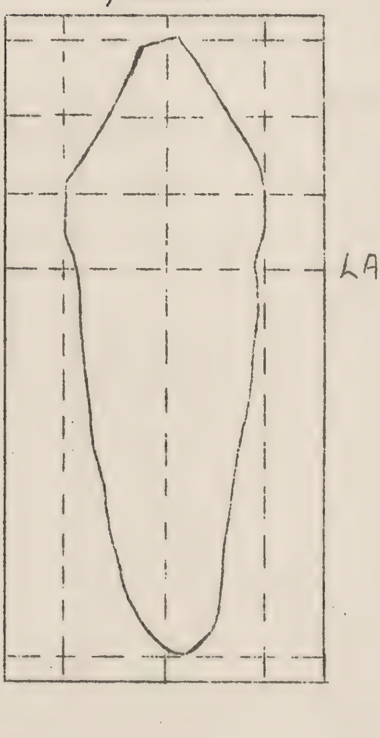


Lingual

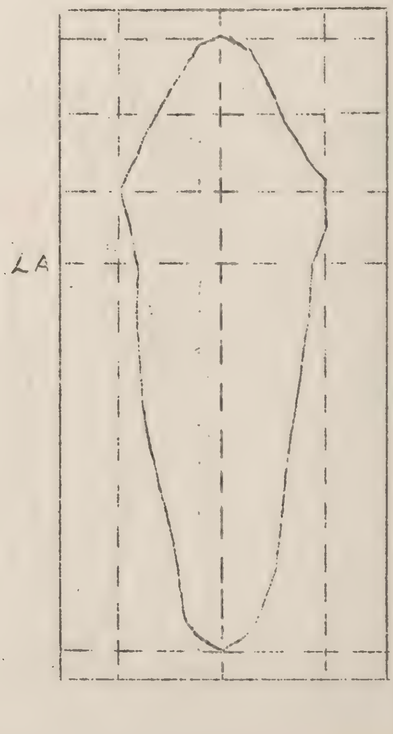


Occlusal

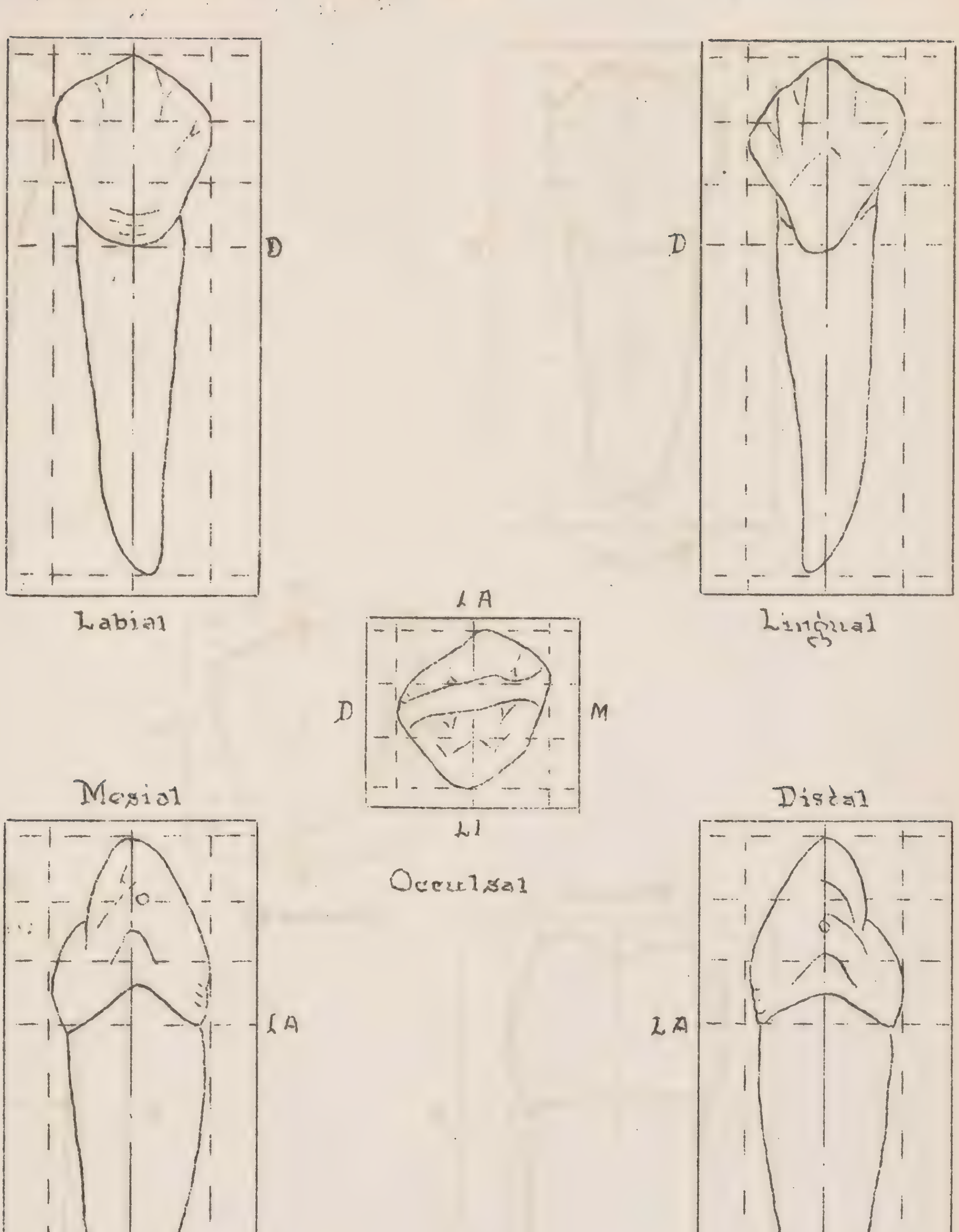
Mesial



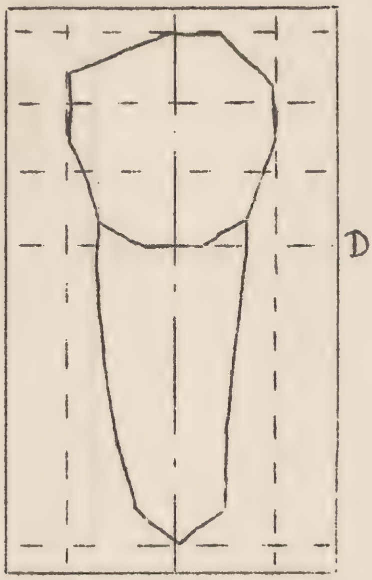
Distal



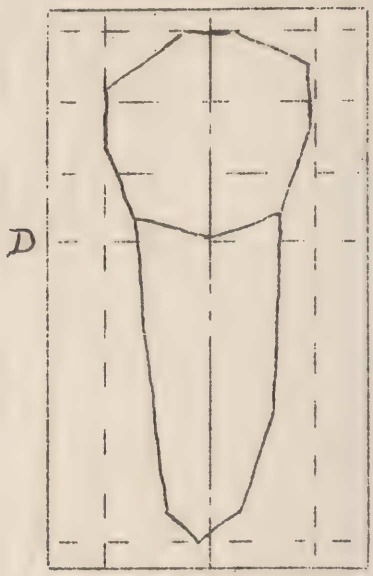
Upper Right Cuspid



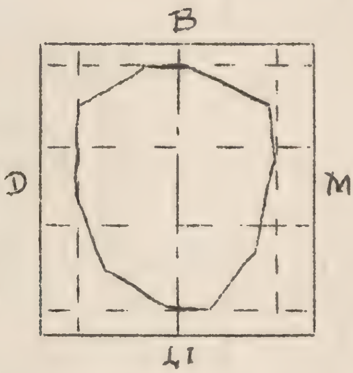
Upper Right First Bicuspid



Buccal

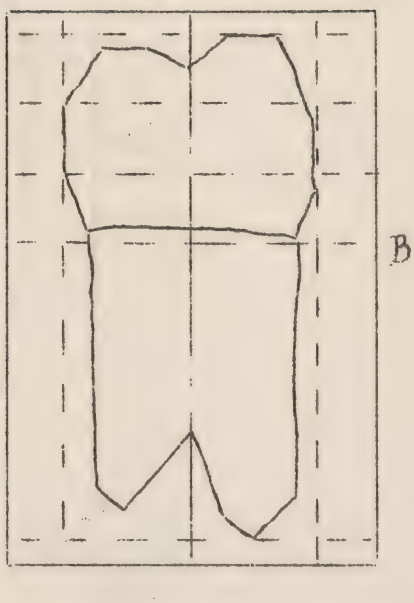


Lingual

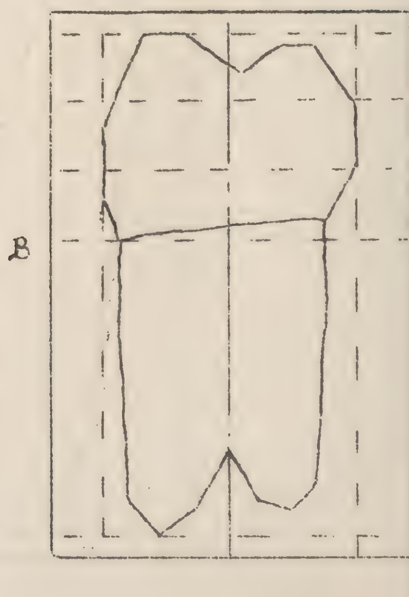


Occlusal

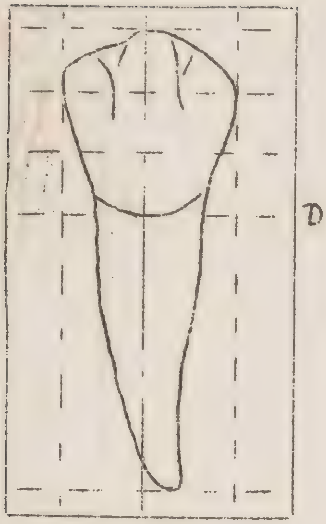
Mesial



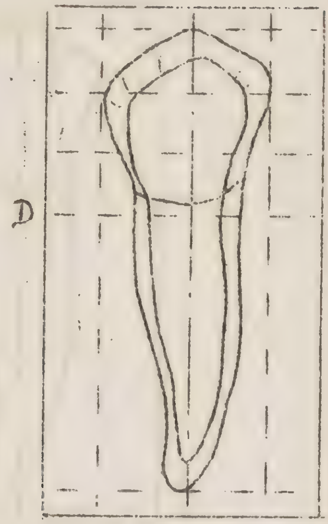
Distal



Upper Right First Bicuspid



Buccal



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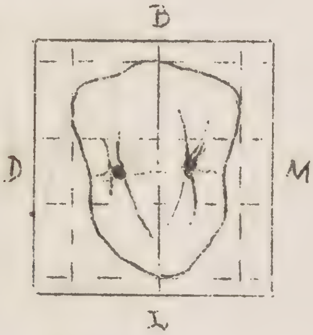
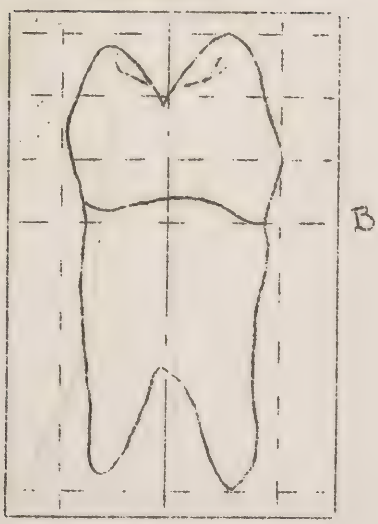


Occlusal

Mesial



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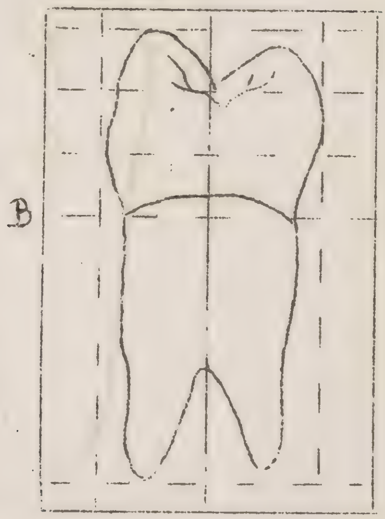
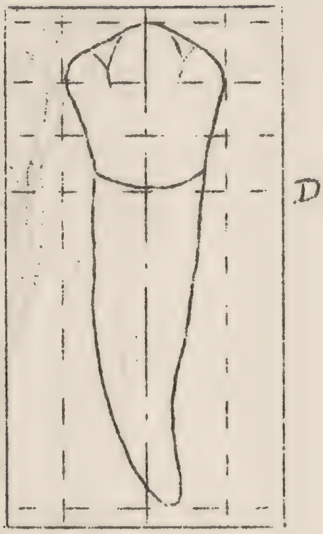


Upper Right Second Bicuspid



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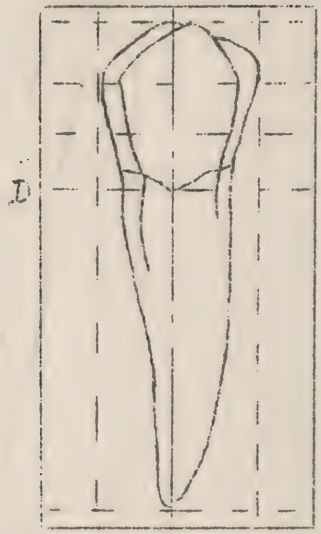
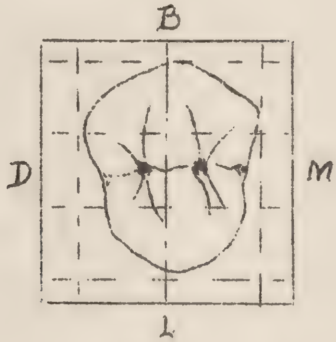
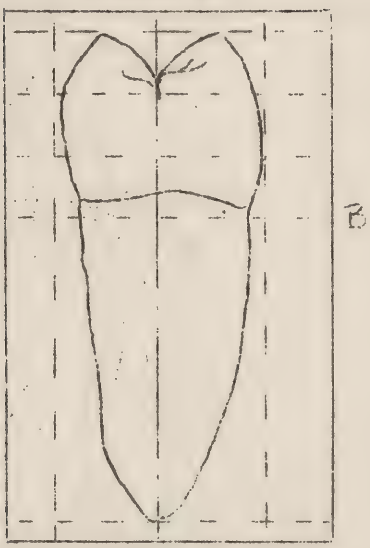


Lingual



Occlusal

Mesial



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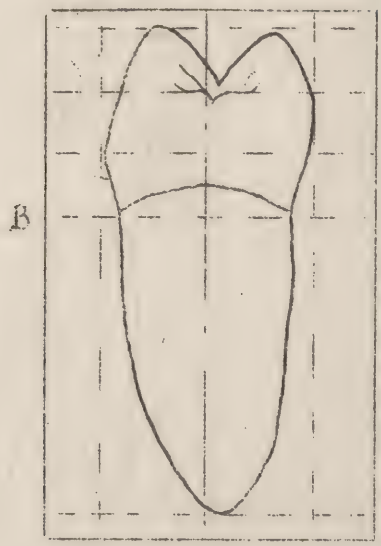
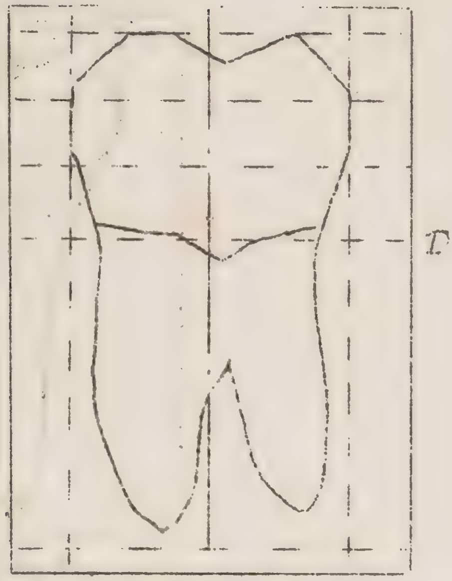
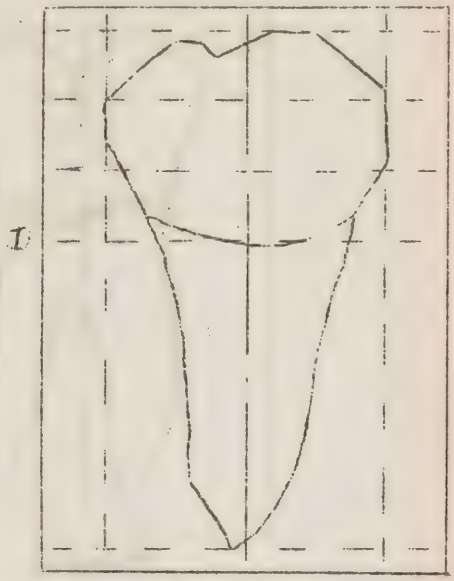


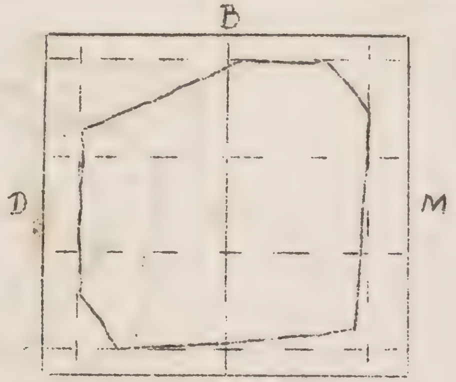
Upper Right First Molar



Buccal

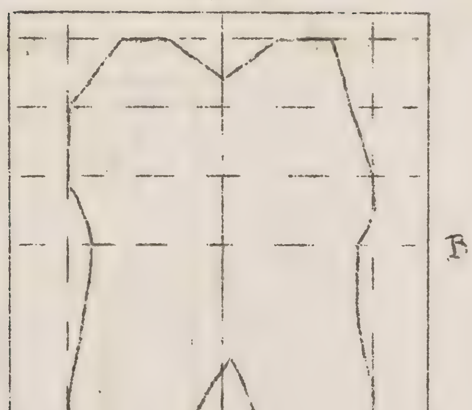


Lingual



Occlusal

Mesial



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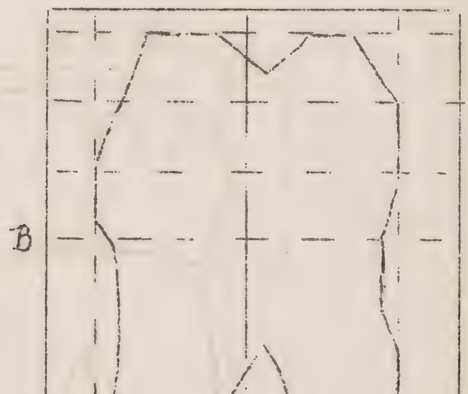
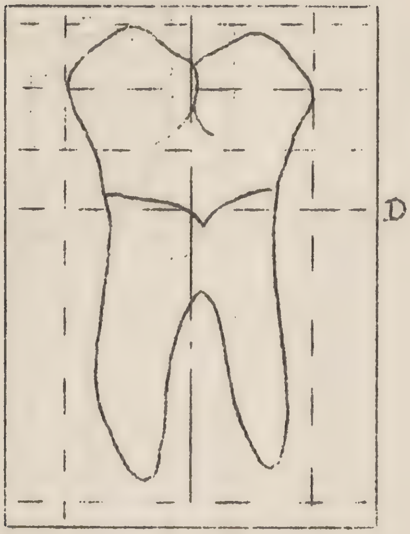
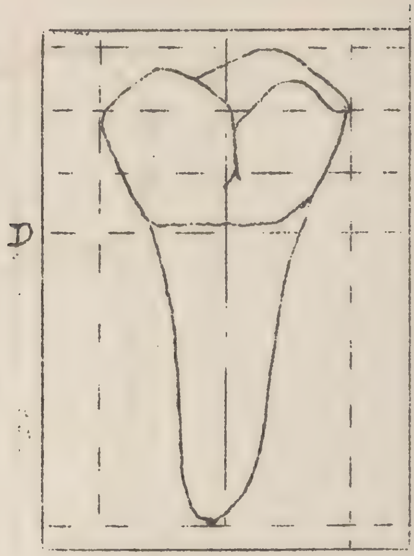


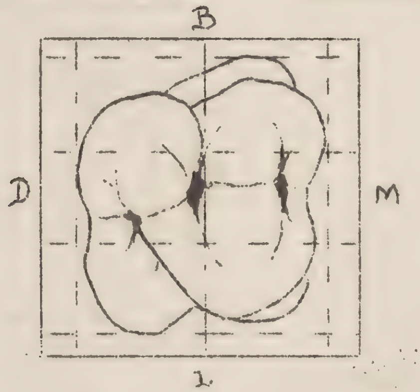
Upper Right First Molar



Buccal

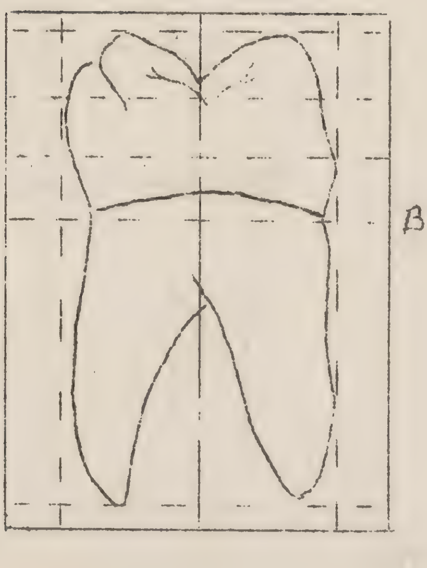


Lingual

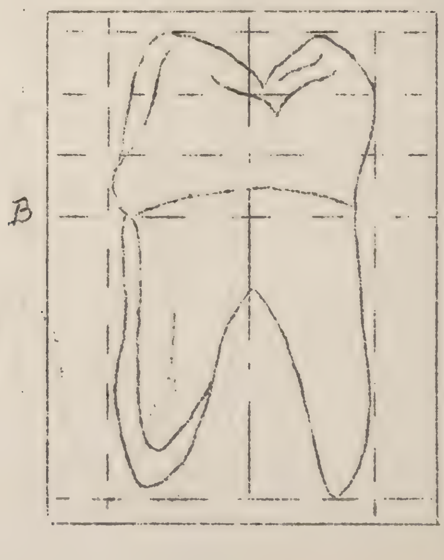


Occlusal

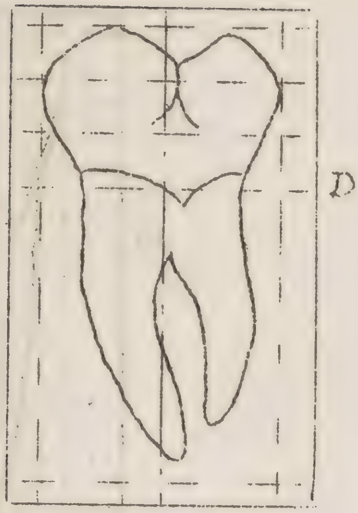
Mesial



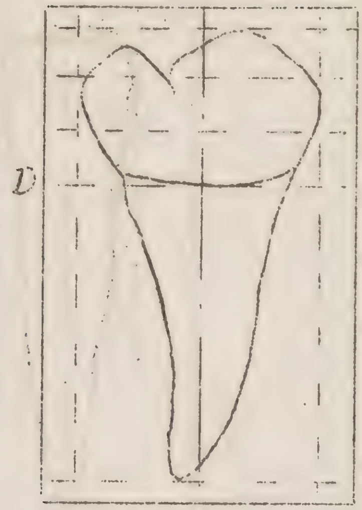
Distal



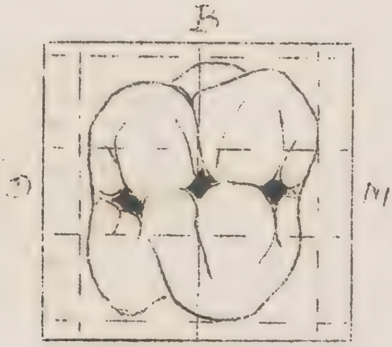
Upper Right Second Molar



Buccal

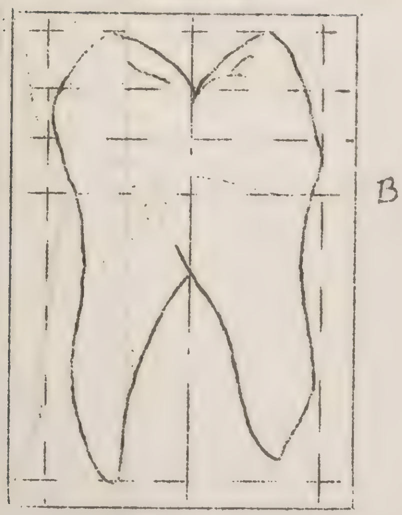


Lingual

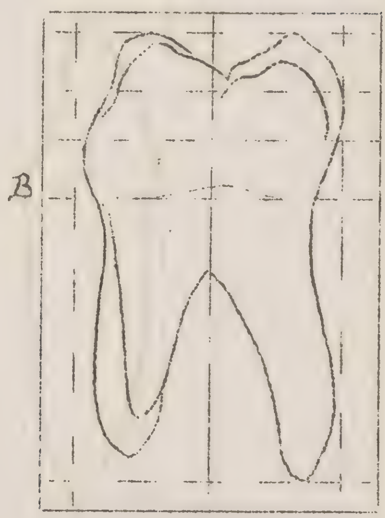


Occlusal

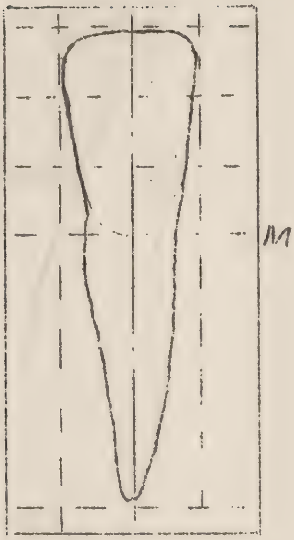
Mesial



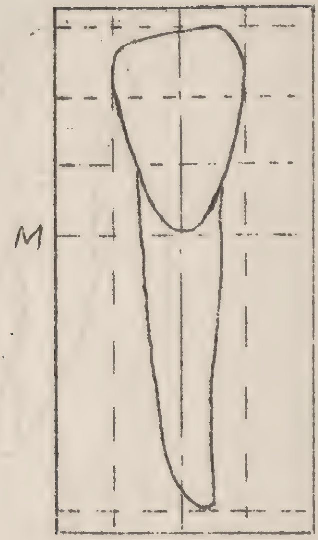
Distal



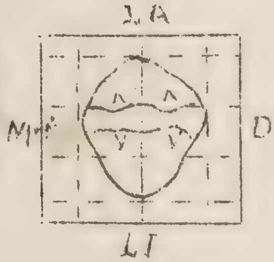
Lower Right Central



Labial

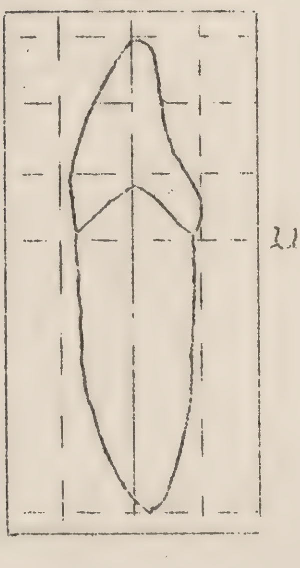


Lingual

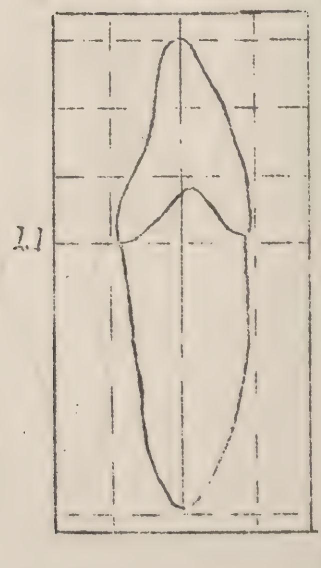


Occlusal

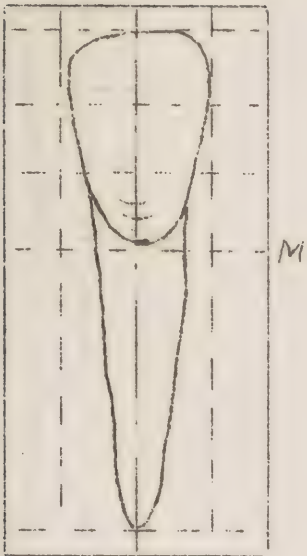
Mesial



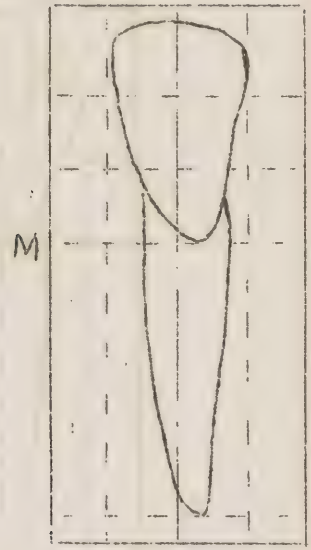
Distal



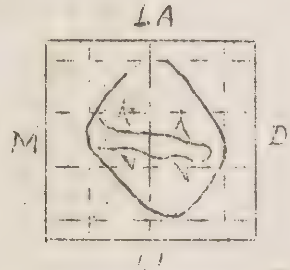
Lower Right Lateral



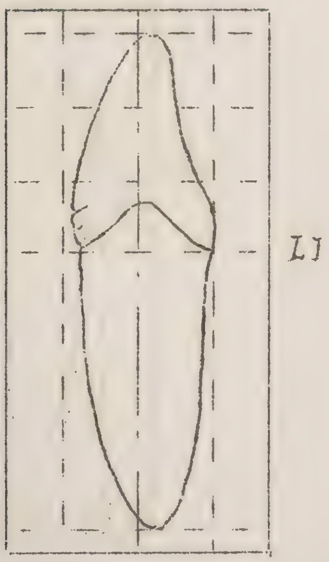
Labial



Lingual

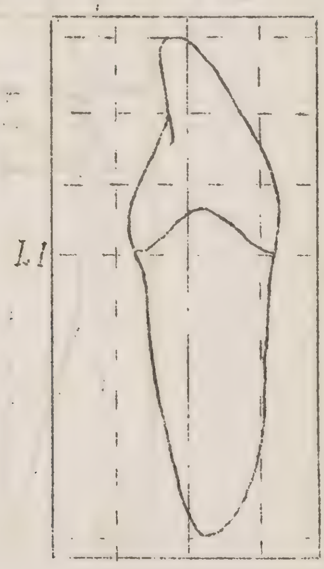


Mesial

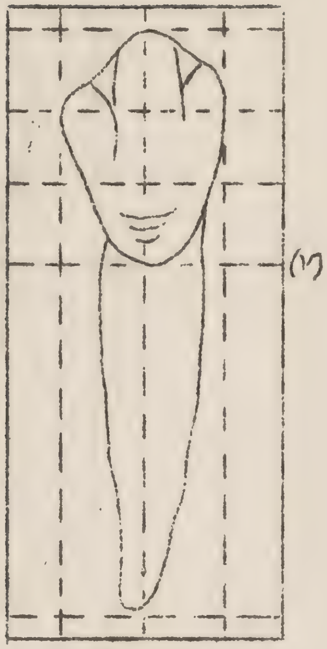


Occlusal

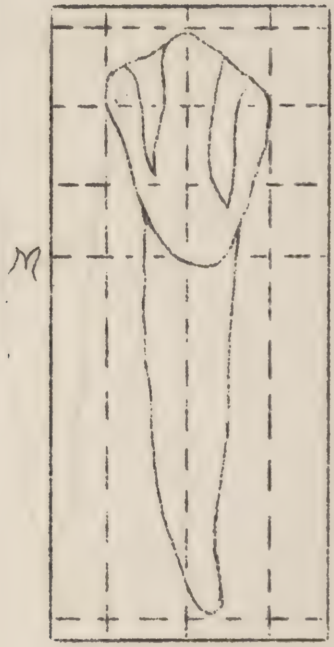
Distal



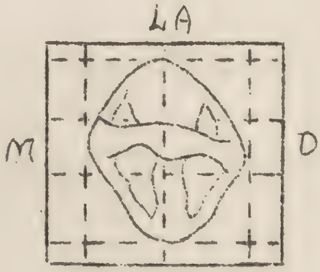
Lower Right Cuspid



Labial

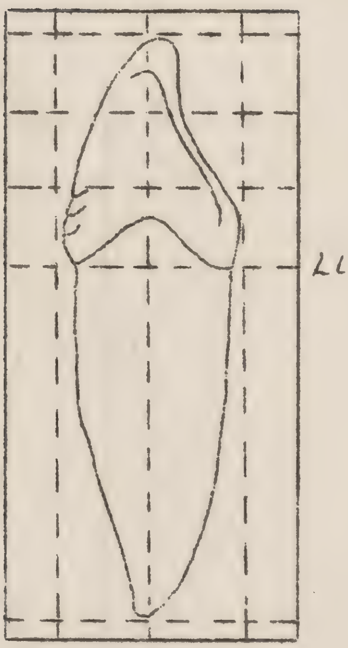


Lingual



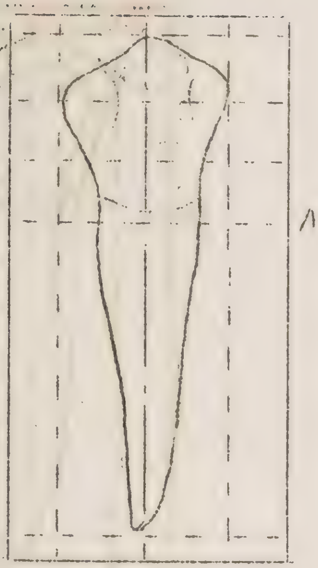
Occlusal

Mesial

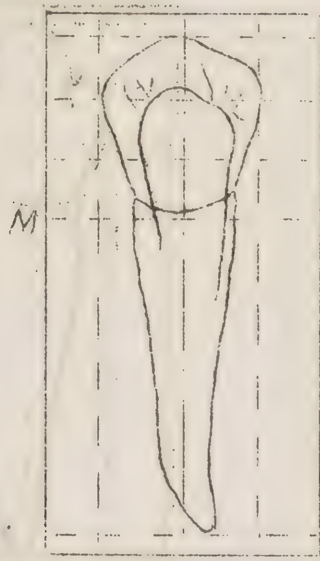


Distal

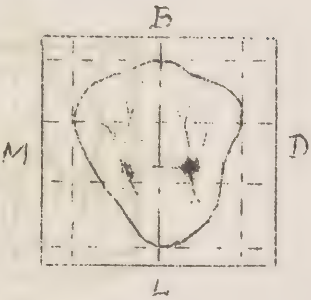
Lower Right First Bicuspid



Buccal

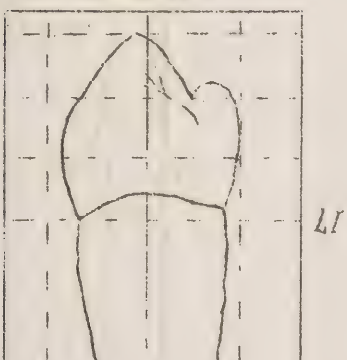


Lingual

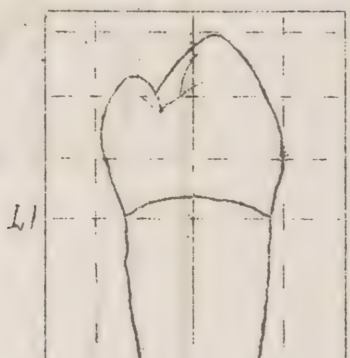


Occlusal

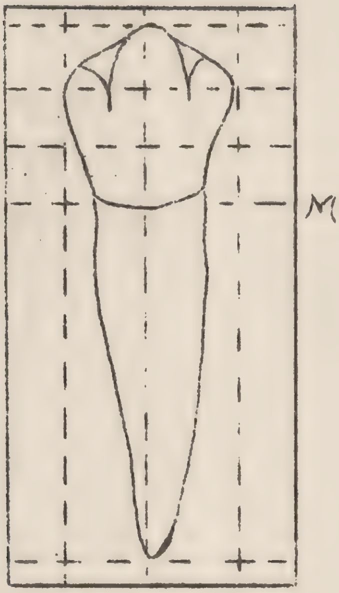
Mesial



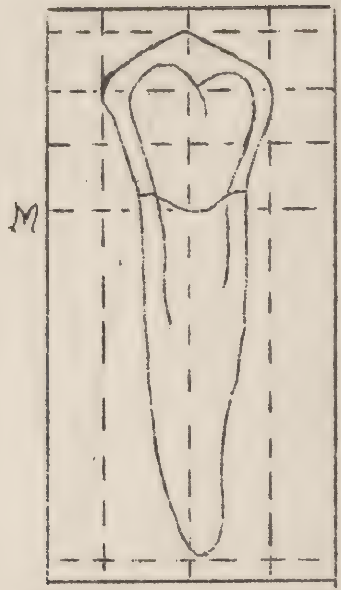
Distal



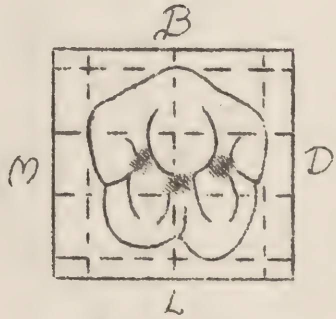
Lower Right Second Bicuspid



Buccal

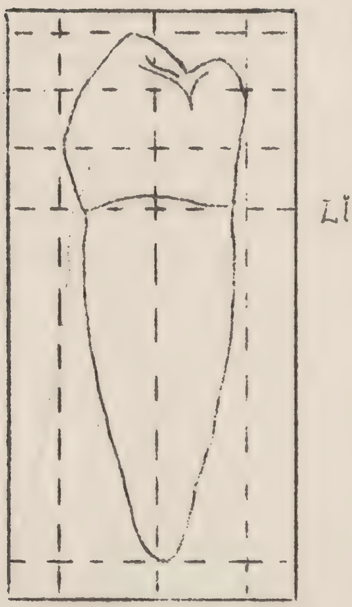


Lingual

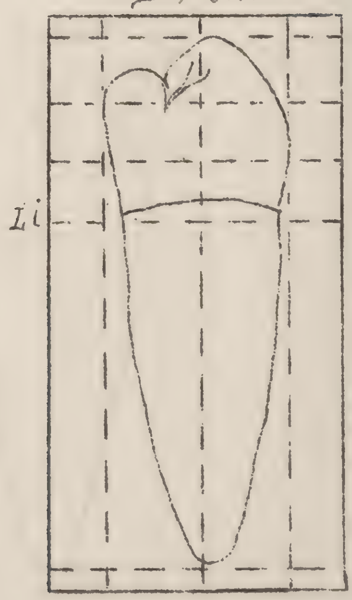


Occlusal

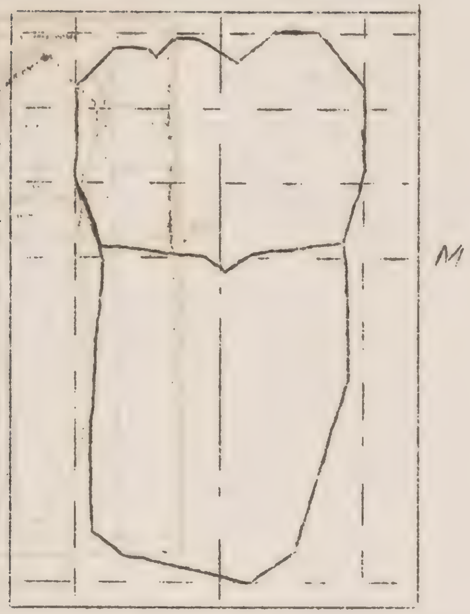
Mesial



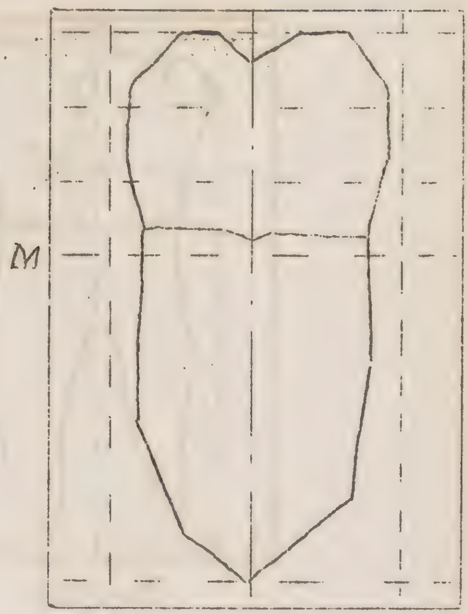
Distal



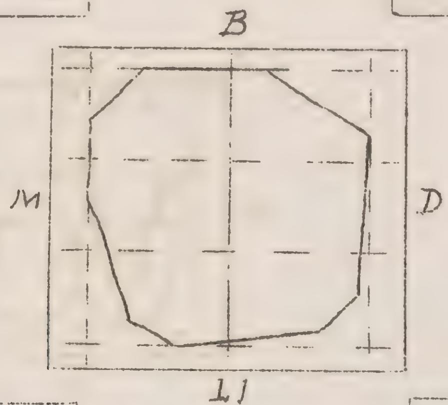
Lower Right First Molar



Buccal

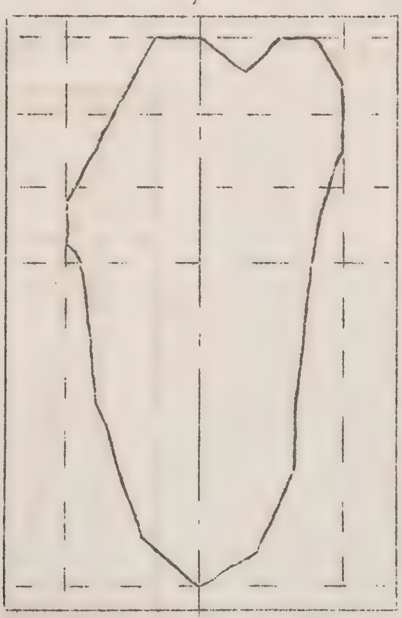


Lingual

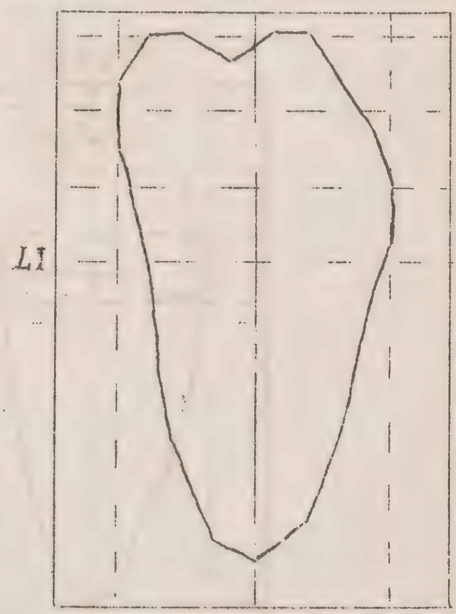


Occlusal

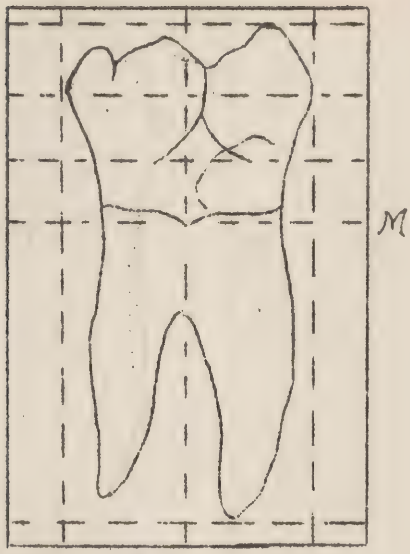
Mesial



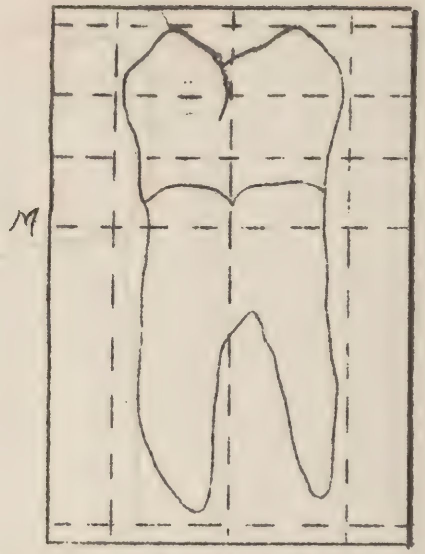
Distal



Lower Right First Molar



Buccal



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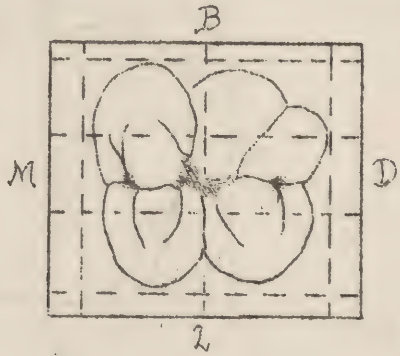
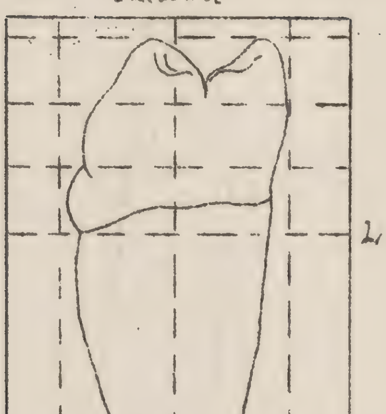


Occlusal

Mesial



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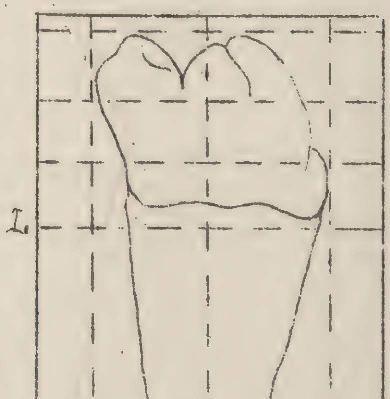
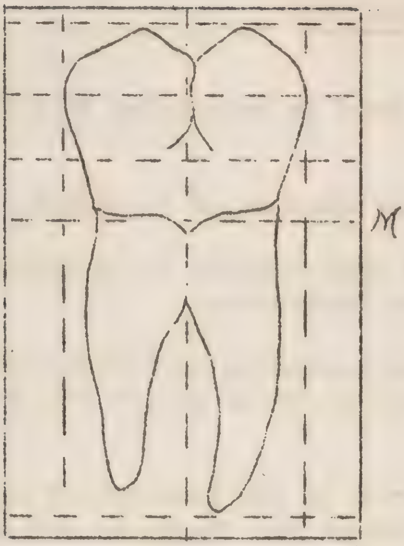
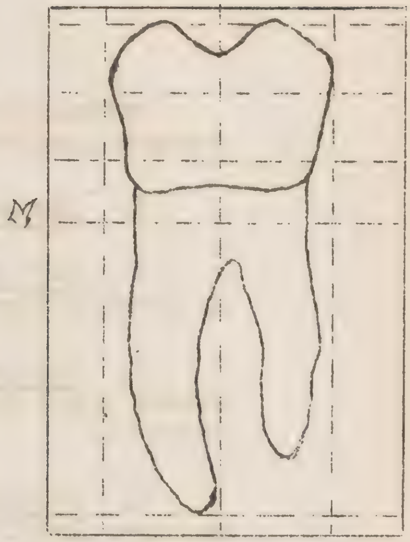


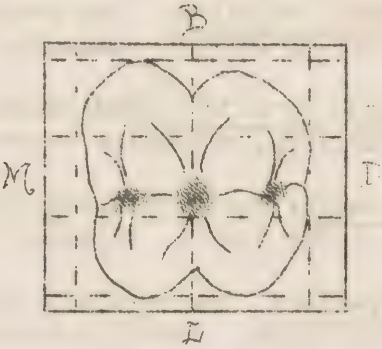
Lower Right Second Molar



Buccal

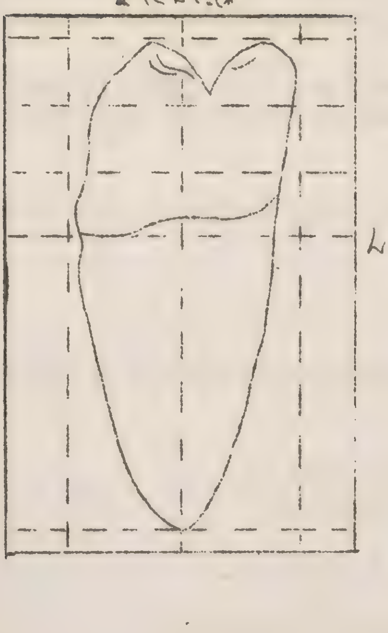


Lingual

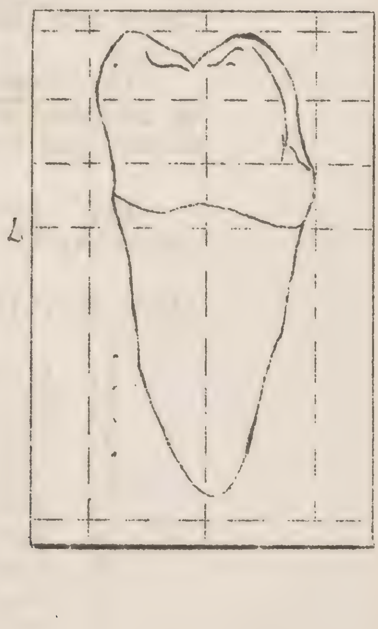


Occlusal

Mesial



Distal



FULL DENTURE CONSTRUCTION

Definitions of terms that are used in connection with full denture construction:

1. Impression: A negative reproduction of an object.

2. Cast or Model: A positive reproduction of an object made by pouring stone or plaster into the impression.

3. Full denture: An appliance replacing all of the teeth in either upper or lower jaws. Commonly known as plates and artificial dentures.

4. Periphery: That border formed by the junction of the cheek and the alveolar ridge. This determines the thickness and length of the flanges or sides of the denture.

5. Centric relation: Most retrusive position of the mandible while at rest from which lateral movements can be made.

6. Gothic Arch tracing: A record of the centric, right and left lateral, protrusive, retrusive movements of the mandible.

7. Over-jet: The horizontal distance the upper teeth extends out from the lower teeth. Normally about $1\frac{1}{2}$ mm.

8. Over-bite: The vertical distance the upper teeth extends over the lower teeth. Normally about $1\frac{1}{2}$ mm.

9. Denture Space: Vertical opening or the normal space between upper and lower jaws. Often referred to as the lost dimension.

10. Base Plate: A temporary denture base that is used as a base or foundation for building bite rims, arrangement and articulation of teeth, and for the try-in.

11. Denture Base: The material that holds the teeth in place and rests on the gum.

Steps in Full Denture Construction:

1. A snap or preliminary impression by Dental Officer.
2. Study model.
3. Master impression tray.
4. Master impression by Dental Officer.
5. Boxing and pouring master model.
6. Base plate bite rims.
7. Temporary centric by Dental Officer.
8. Mounting on articulator.
9. Find centric relation by Dental Officer.

10. Remount on articulator.
11. Selection of teeth - arrangement and articulation.
12. Contour wax.
13. Try-in by Dental Officer.
14. Final waxing and contour.
15. Flasking.
16. Packing and cure.
17. Trimming and polish.

Step No. 1

The snap or preliminary impression is usually taken in modeling compound (commonly known as compound). Its purpose is for the study and planning of the case. These impressions are taken by the Dental Officer and sent to laboratory for Step No. 2.

Step No. 2

Pour snap impression in Plaster of Paris. It is then trimmed and made ready for an outline. This outline is to be used for the making of an impression tray with which Dental Officer takes his master impression.

Step No. 3

There are various types of trays that can be used:

1. Kerrs green adaptable tray.. This is a thin aluminum tray that can be adapted or burnished to fit over the snap impression.

2. Fusable metal tray. A wax liner is adapted over the model and trimmed to the outline. Over this a base plate wax pattern for the impression tray is made. This is removed from liner and model and a split plaster mold is made. The molten low fusing metal is then poured into the mold through a sprue hole leading to the pattern. After cooling, the tray is trimmed and smoothed.

3. Vulcanite and Acrylic tray: These are made from wax patterns, invested, cured and trimmed. These can be made either of vulcanite or acrylic.

4. Cast tray. Made from a wax pattern taken from the snap. This is invested in an ordinary crown and bridge investment, heated, and cast in aluminum or type metal.

5. Compound tray. Made out of compound over the wax liner on snap impression, chilled, and trimmed.

Step No. 4

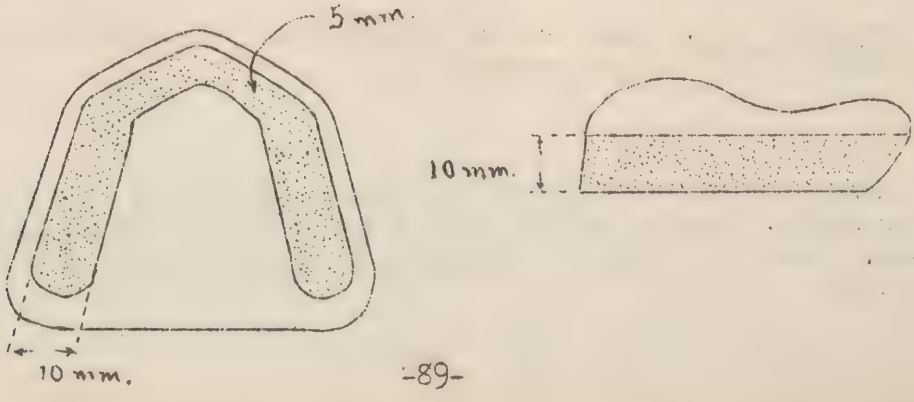
The impression tray is used by the Dental Officer to take the master impression. Anyone of the several types of impression material may be used. Namely, Plaster of Paris, prepared impression plasters and compounds.

Step No. 5 Boxing and Pouring:

A thin strip of utility wax about 1/8 of an inch wide is adapted about 2 mm. below the peripheral edge of the impression. Seal this in place with a hot spatula. A strip of boxing wax or tin is then placed around the impression and sealed into position. On the lowers the lingual space is filled with base-plate wax. The width of the boxing strip should be at least 1/2 inch above the periphery, so that the base of the model will be the proper thickness. Quick setting stone is mixed to a thick cream consistency and vibrated into the impression. Allow the stone to set for at least 20 minutes or until no further heat is generated. To separate, first remove the boxing wax, and if compound impression material is used the tray may be removed by placing in hot water. If a plaster material is used by the Dental Officer, it must be painted with a staining and separating fluid before pouring in the stone. To separate cut carefully to the stained portion of the impression material, and then chip away the remaining plaster.

Step No. 6 Base-plate and bite rims:

Base-plates are adapted over the upper and lower models by the use of dry heat. They are adapted and trimmed so that there is approximately 2 mm. excess which can be folded over at the periphery for strength and as a seal for the base-plates. The model must be soaked in water before the base-plates are adapted to prevent sticking of the shellac base-plate to the cast. Base-plate wax is then formed into horeshoe-shaped blocks and seared to the ridges of the base-plate with sticky wax. The wax ridges are trimmed to the following dimensions: 5 mm. wide in anterior region - 10 mm. wide in posterior region - approximately 10 mm. high. This same technic would apply to the use of compound in place of wax.



Step No. 7 Temporary Centric by Dental Officer.

The bite blocks or rims are placed into the patient's mouth by Dental Officer; cut and trimmed to the correct size. The denture space is then determined. The midline, lip line, and the corners of the mouth are marked on outer surface of the bite blocks. They are then tacked or sealed together, removed and sent to the laboratory.

Step No. 8 Mount on Articulator.

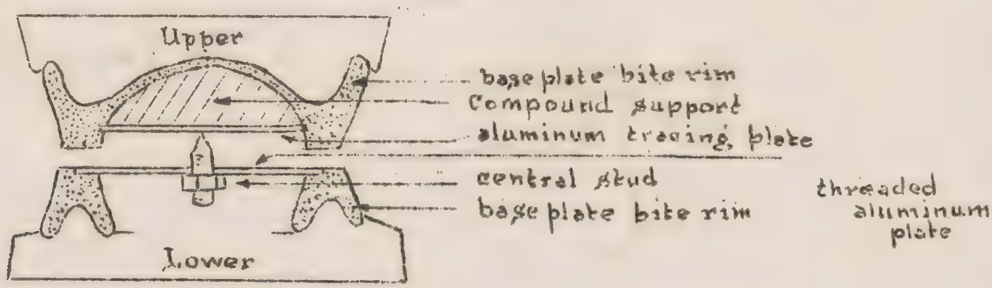
The base plates are then placed back on the models and sealed in position. These will be mounted on the articulator with Plaster of Paris so that it is centered. The plane of occlusion is the midline and parallel to the base of the articulator.

Step No. 9 Final Centric Relation by Dental Officer.

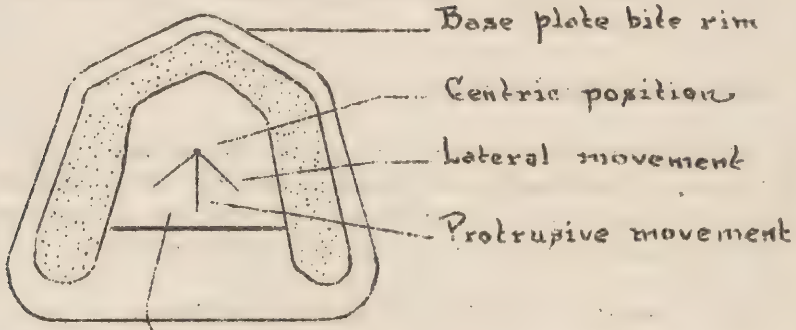
Centric Relation Plates.

Two types are generally used, the intra-oral and the extra-oral. Both are essentially the same in that they both have a central bearing stud.

1. Intra-oral. This is most commonly used with the Gysi-symplex articulator. The Centric Relation plates consist of two parts; a lower wing-shaped part with a central stud which is threaded and can be raised or lowered; an upper part which is a thin piece of aluminum cut to fit in the palate of upper base-plate and is supported by compound. Measure the distance from the plane of occlusion to some point on the articulator. This distance is marked and a record is made. The wax rims are then trimmed on the occlusal surface to prevent interference during the movements of the mandible. The upper and lower parts of the centric relation plates are then seared into the wax ridges so that they are parallel with one another and the central bearing stud is brought up into contact with the upper plate when the articulator is closed.

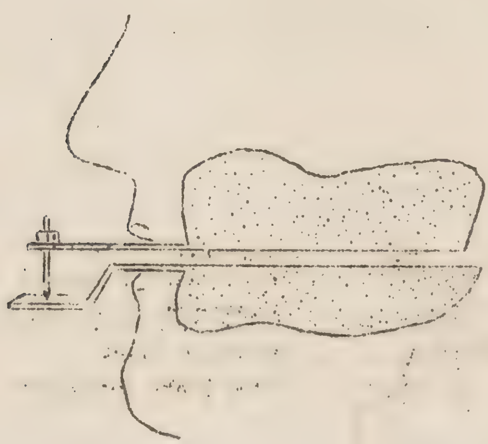


The gothic arch tracing, which is the recording of the movements of the mandible from its most retruded position, is scratched upon the aluminum table by the central bearing stud. The two plates are locked in the centric position by a mix of Plaster of Paris.



Gothic Arch Tracing

2. Extra-oral. The essential difference between these two methods is that the extra-oral method has a tracing table on the outside of the mouth; and the tracing is made in wax on this table or by carbonizing the table by a sharp pin which extends from the upper part.



Extra-Oral

Step No. 10 Remount on Articulator.

Either the upper or lower cast is removed and remounted to this new and more perfect relationship. This step would be carried out only when the change is slight. If there was a great change, both upper and lower casts should be removed to remount the case.

Step No. 11 Marking of Bite Rims after being returned from the Dental Officer.

1. Locate and mark on lower cast center of ridge in third lower area and bicuspid area. Draw a line connecting these two points.

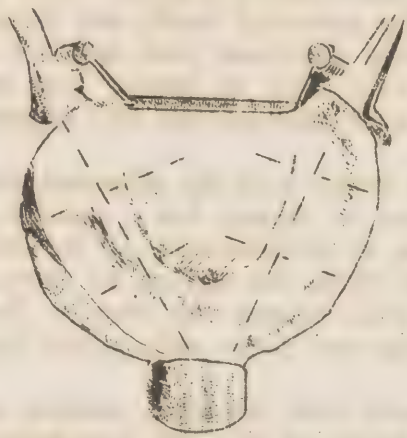


FIGURE A.

2. Place wax bite rim on cast and reproduce this line on occlusal surface of rim.

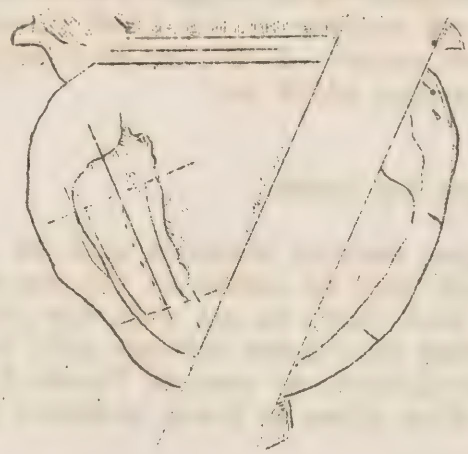


FIGURE B.

3. In a similar manner locate and mark center of ridge in anterior region.

4. In the second molar region mark a point 5 m.m. bucally from the central line, also one $2\frac{1}{2}$ m.m. in the bicuspid area. Connect these points. See Figure B.

5. Conform the lower bite rim in the anterior region to the curved contour of the upper. (Made by Dental Officer). The necks of the lower teeth must be over the ridge as nearly as practical.

6. The occlusal plane in the posterior region should bisect the lost dimension. Unless otherwise designated by the Dental Officer the same rule applies in the anterior region.

Step No. 12 Selection of teeth and their arrangement and articulation.

The baked porcelain teeth available come in varying shades, shapes, and sizes. The anterior teeth are retained in the denture by means of gold plated, platinum pins and are known as pin teeth. The posteriors which vary only in shape, size and shade, are retained by undercut holes or diatorics and are known as diatoric teeth.

1. The anterior teeth will be selected from one of three general classifications of shape, i.e., square, tapering, and ovoid. The size will be given in millimeters as to length from collar to incisal edge and width from the mesial to distal surfaces. From this information you will select the teeth. For example, a tapering tooth 10.5 mm. long and 9 mm. wide could be selected as mold 4N.

2. Posterior teeth come in long, medium and short. The size is given as the width of the two bicuspids and two molars in millimeters. For example, 32 M. would be medium (M) length teeth, 32 mm. from the mesial surface of the first bicuspid to the distal surface of the second molar. A 32 L or 32 S tooth would either be long or short as the case might be.

Step No. 13 Setting the Teeth.

1. The two upper central incisors will be set on each side of the midline, which will be marked on the wax ridge. The upper six anterior teeth will first be set with the labial surfaces flush with the outer surface of the wax rim and with the incisal edges along the line of occlusion, as seen in Figure 1. Figure 2 demonstrates the inclination given to these anterior teeth.

2. The upper posterior teeth are set in as shown in Figure 3. A space of approximately ½ an mm. is left between the cuspid and first bicuspid. The buccal margin established on the lower wax bite rim should be directly under the buccal cusps of the upper posteriors when they are properly set.

3. <u>Compensating Curve</u>.

A compensating curve used in setting the posteriors provides for better balancing of the dentures, especially in the protrusive bite. It is developed as shown in Figure 3, by proceeding as follows:

4. Set buccal cusp of first bicuspid on wax rim leaving lingual cusp raised slightly. Set second bicuspid with both cusps touching lower bite rim. Set first molar with mesio-lingual cusp in contact. Remaining cusps elevated approximately 1 mm. Set second molar with lingual cusp in contact or slightly raised if greater compensating curve is desired. The buccal cusps conform to the curve set by the first molar. The relationship of the opposing cusps is shown in Figure 6.

5. <u>Setting the Lower Posterior Teeth</u>.

Commencing with the lower first molars they are set in occlusion as shown in the rest bite position, Figure 7. The second bicuspid, first bicuspid, second molar are next set in.

6. The lower anteriors are set in the following order, cuspids, laterals, centrals. (See Figures 4 and 5).

7. Correct balancing and working bite, demonstrated when the condoiles of the articulator are depressed is obtained by proper inclination and rotation of the long axis of the teeth, as shown in Figures 8 and 9.

FIG. 1

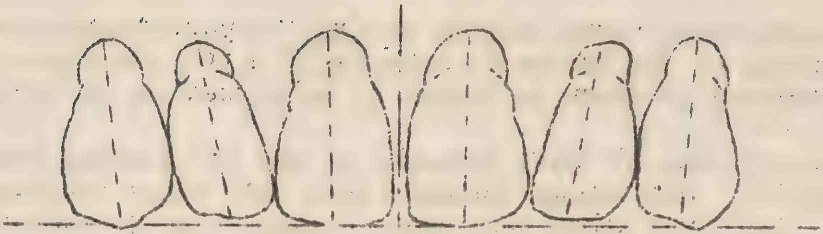
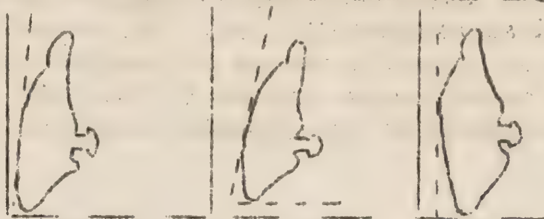


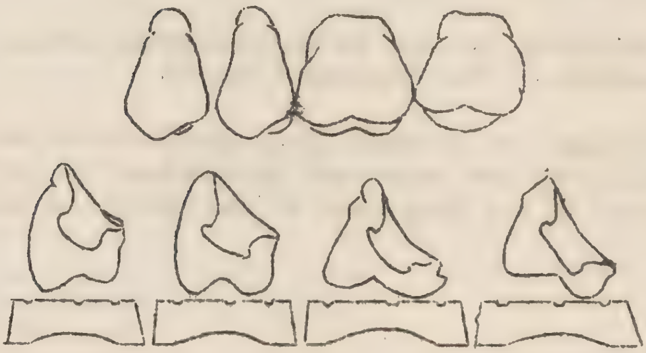
FIG. 2



Central Lateral Cuspid

CUSPID RELATION

FIG. 3



LOWER ANTERIORS

FIG. 4

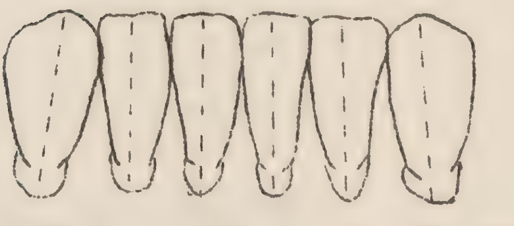
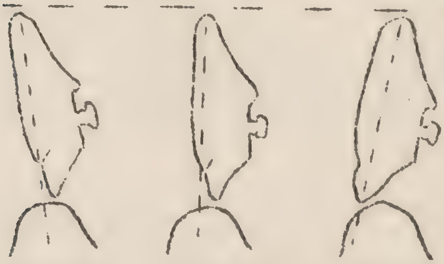


FIG. 5



Central Lateral Cuspid

FIG 6

FIG 7

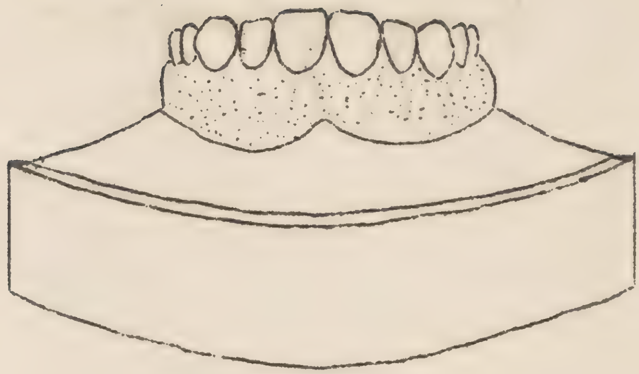
Rest Bite

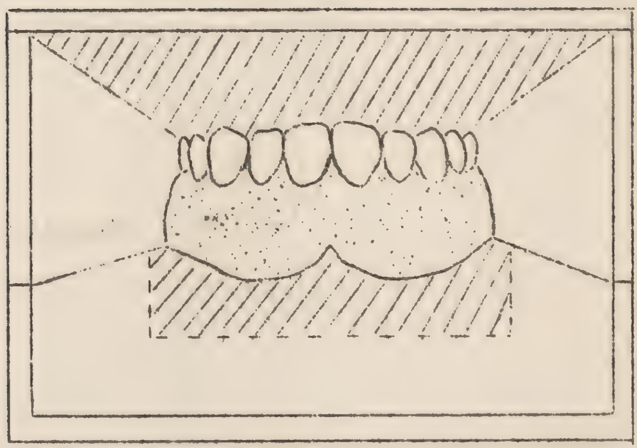
FIG 8

Working Bite

FIG 9

Balancing Bite





Step No. 14 Contouring for Try-in

After the set up is complete, you will contour the wax to resemble natural gum tissue. About two layers of wax are softened and molded around the necks of teeth and extended to the periphery of the denture. After cooling, the wax is then carved so as to represent the eminences formed by the roots of the teeth. The cuspid eminence is especially prominent, and care should be taken that all of the teeth are free of excess wax. Flush wax with a small flame, cool, and polish with a cloth. Caution, do not remove from the model during this step.

Step No. 15 Try-in by the Dental Officer

The case is tried in the mouth and the mechanics and esthetics are checked. If everything is found to be correct, it is returned to the laboratory for completion. If any errors are found you will have to correct them by repeating some of the previous steps.

Step No. 16 Final Waxing of the Denture

Final instructions received from the Dental Officer concerning the desired thickness of the flanges and the contouring will be applied here. If a rugae is ordered, you will either carve one; or if commercial rugae packs are available, you will place one of these in the palate of the denture. Using sticky wax, you seal the dentures to the models. After all contouring of the wax is completed, you remove the case from the articulator.

Step No. 17 Flasking and Separating.

After soaking the model in water, we invest the model in plaster in the lower half of the vulcanizing flask. See figures on Page 97.

Tin foil is then closely adapted to the wax denture in such a manner that none of the wax portion remains exposed and one-third of the axial surface of the teeth are covered. The exposed plaster surfaces are vaselined. Following this, the upper half of the flask is put in place over the lower half and is filled with Plaster of Paris. The cover is put in place, so that we have a completely enclosed flask, which, when heated, can be separated into two halves.

The entire flask is placed in a kettle of boiling water and allowed to remain five minutes, or is placed in cold water and allowed to come to a boil. It is removed and the two halves gently separated. The wax and the adapted baseplate are removed. The wax residue is cleaned off by flushing the case with boiling water. The teeth are then embedded in the upper half of the flask, while the model remains with the lower half.

Step No. 18 Packing and Curing

1. Vulcanite - The flasks are reheated to facilitate packing. Pink rubber is packed first and will be placed on the facial side of the denture. It is first packed around the teeth in small triangles.

After a sufficient amount has been placed, two strips which entirely face the denture, are placed in position. This can now be tested by placing a sheet of cellophane over the rubber, placing cotton rolls over the ridge areas, closing the flask in a spring clamp, and placing in boiling water for five minutes. The dark rubber is then packed over the entire surface. The case is then tested without using cotton rolls. This procedure is repeated until the correct amount of rubber has been used and the two halves of the flask are closed. The model is then tinfoiled, the case closed and vulcanized under a steam pressure at a temperature of 300° F. for two and one-half hours.

2. Acrylic Resin - When this material is used the model is tinfoiled before packing the case. The material is available in the blank or powder and liquid form. The blank is ready for use, but the powder and liquid must be mixed together according to the directions given by the manufacturer. Lucitone is the material which is generally used; and the following instructions are for this material only:

a) Paint "Di-Tol" into the approximal spaces, exposed surfaces of the teeth, and include about ½ of an inch above gingival line on the tin foil of both the lingual and the labial (buccal) surfaces. Be sure that the pins on anterior teeth are covered. Be liberal in applying "Di-Tol", using three coats as outlined above.

b) Allow flask to cool to 110° F. This temperature is just slightly warm to the touch.

c) The correct proportion for a mix is 30% liquid (manomer) to 70% powder (polymer) by weight. One unit for one denture would be 30 cc. of powder to 9.6 cc. of liquid.

d) Pour the powder and the liquid into the mixing jar and mix thoroughly using a glass stirring rod. Place the lid on the jar and allow the mix to stand until it reaches a plastic or doughy consistency. This time that we allow it to stand varies according to the temperature of the room, but approximately three minutes is the average time.

e) Remove the mass from the jar and knead the Lucitone with <u>CLEAN</u>, <u>DRY</u> hands for approximately one minute.

f) The packing temperature of the flask is approximately 100° F.

g) Form the material into a roll. Pack the case by pressing the material into position with your index fingers.

h) Cover the Lucitone with a sheet of damp cellophane for trial packing.

i) Open the flask, remove the cellophane, and trim the excess Lucitone to 1/8 inch from the periphery. Place the assembled flask in a bench press for the final closing of the flask.

j) Curing technic. Submerge the closed flask in cool water, bring to a boil in not less than one hour and continue boiling for 45 minutes.

k) Cool the flask slowly. It is best to allow the flask to "bench cool" (cooling to room temperature by standing.)

Caution in handling acrylics: Do not spill the liquid on the hands. Avoid prolonged inhalation of the fumes by working in a well ventilated room. The liquid is inflammable so keep it away from fire and open flame.

Step No. 19 Trimming and Polishing

1. Remove the denture from the flask, and carefully remove all the plaster from the denture.

2. The excess material is removed using arbor bands, sand paper, files, and burs. Care should be taken not to destroy the peripheal extremity of the denture.

3. Trim around the necks of the teeth with burs or trimmers, until the entire facial surface of the teeth is exposed. Care should be taken not to go below the gingival marking of the teeth and not to remove too much material from the interproximal spaces. Use sharp instruments as a dull trimmer leaves a rough surface and is hard to polish.

4. Polishing is done on a lathe, using first coarse pumice, then fine pumice, tripoli (if procureable), and finally tin oxide or chalk for the high polish. Care in using the pumice must be exercised as it is easy to wear away a great deal of the denture material and ruin the denture.

CHAPTER III

PARTIAL DENTURE CONSTRUCTION

A partial denture may be defined as a denture that replaces one or more of the lost natural teeth in either arch and is usually retained by mechanical means against the remaining natural teeth.

Partial dentures are classified as:

1. Tooth Borne

   Those partial dentures that are entirely supported against the forces of mastication by the teeth. They have anterior and posterior abutments which have occlusal rests. (See clasps)

2. Tissue borne

   Those partial dentures that have no occlusal rests and are entirely supported by the tissue.

3. Combination

   Those partial dentures that have occlusal rests on the clasped tooth, but are also supported by the tissue under the saddle, behind which there is no abutment tooth.

Each of the above classifications permits the use of several types of partial dentures.

Types of Partial Dentures:

1. One Piece Castings

   Where clasps, bar and saddles with teeth attachments are all cast in one piece. These are also called all-metal cases.

2. Cast Skeleton plus Material

   Where clasps, bar and retention for saddles are cast in one piece. Denture base material is used here for saddles.

3. Assembled Skeletons plus Material

   Where clasps and Palatal or lingual bar are adapted and used for the skeleton.

4. Horse Shoe (Uppers and Lowers)

Where only clasps are used, and denture base material replaces the bar by extending in the palate in the shape of a horse shoe. Lowers without a bar are seldom used; although in the case of an emergency, they could be constructed and would temporarily serve the patient.

5. Retention Plate

A temporary partial without clasps or bar. These partial dentures are ordinarily constructed to fill the space of missing teeth for appearance until a more permanent partial can be constructed.

Parts of Partial Dentures

1. Teeth

Teeth of correct shade and size, which are to replace the lost teeth, are selected and placed in occlusion. It is generally necessary to grind these teeth with stones for proper alignment and articulation.

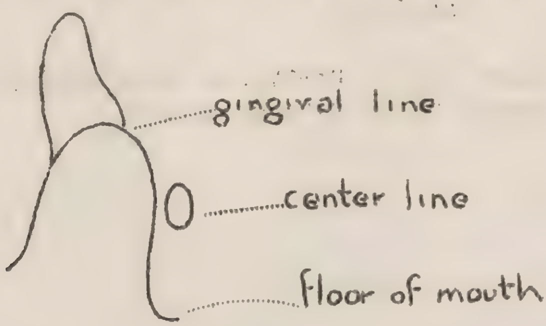
2. Saddles

The material which covers the ridge area of the denture and in which the teeth, clasps and bar are embedded. This may be either metal or plastic material.

3. Parts Connecting Saddles

That part of a partial denture which connects the saddle areas. In a lower partial denture it may be a metal lingual bar; in the upper it may be a palatal bar, or in the case of a plastic material partial denture it may be of the same material as that of the saddle.

The lingual bar is usually placed slightly above the center of the space between the gingival line and the floor of the mouth. It is always set approximately 1 mm. from the tissue.



The Palatal bar is placed on a line drawn between the right first and second molars and the left first and second molars. Care must be taken to give relief over the median raphe; so the bar would be away from the tissue 1 mm. or more at the median raphe area and gradually tapering in toward the tissue on both ends approaching the saddles.

Wrought bars are adapted to the correct form by using bending plyers.

Cast bars are constructed by casting wax patterns.

4. Clasps

The mechanical attachment of the partial denture to the natural teeth. These are either cast or wrought.

Clasps function according to their design. Their purpose is to stabilize the denture from the dislodging forces exerted while the patient masticates food. The two most common of these forces are leverage and drag. Leverage is generally neutralized by the elimination of fulcrum and drag resisted by the placing of the clasp arms in suitable undercut or retentive areas of the teeth. Making these determinations is called surveying and designing the case and will be demonstrated and explained in detail during the Assembled Partial Denture instruction.

Clasp Materials

Wrought Clasps:

Half-round Clasp Wire, 14 Gauge.
Round Clasp Wire, 16 or 18 Gauge.
24 K. 36 ga. Gold Plate. (Used in Occlusal Rests)
Lug material may be any metal of sufficient strength and Karat.

Cast Clasps:

Any alloy possessing elasticity, hardness and tenacity.

There are a variety of clasp materials used in dentistry, either white or gold color.

Clasps are named according to their design as follows:

(a) <u>One Arm Clasps</u>

These clasps have a single arm which is usually placed on the facial surface of a tooth. (Figure 1)

(b) <u>Two Arm Clasps</u>

These have two arms, one arm on the facial surface and the other on the lingual surface. Without occlusal rests attached the partial denture is therefore tissue borne. (Figure 2).

(c) <u>Three Arm Clasps</u> (Figure 3)

Three arm clasps are essentially two arm clasps with an extension that covers a small area of the occlusal surface. This third arm is known as the occlusal rest.

(d) <u>Crib or Basket Clasp</u>

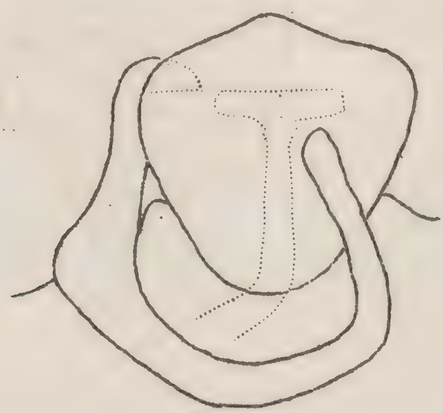
In this type of clasp the body lies in a specially ground embrasure on the occlusal surface of the teeth. The arms extend facially and lingually as in other types. It may be either a single or a double clasp.

(e) <u>Roach Design Clasps</u> (Figure 4)

The roach design is a combination of several different types of clasps. Generally they are classed under seven distinct types. C, L, U, S, T, I, R.

5. <u>Lugs</u>

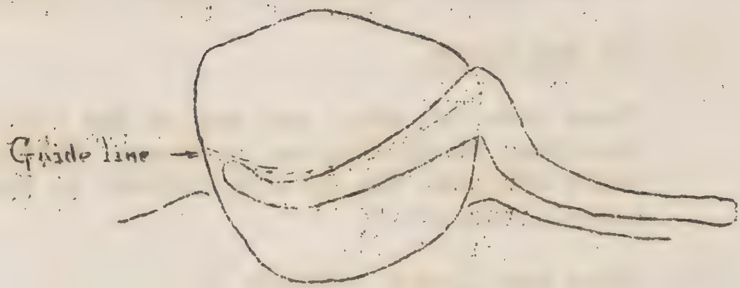
Those parts which connect the clasps to the saddle part of the denture. They are usually soldered to the clasps and embedded in the plastic material of the saddle areas, although they may be soldered to the parts connecting the saddles.



One Arm

Clasp

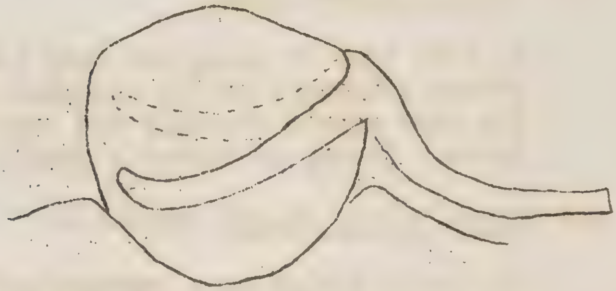
FIG. 1



Two Arm

Clasp

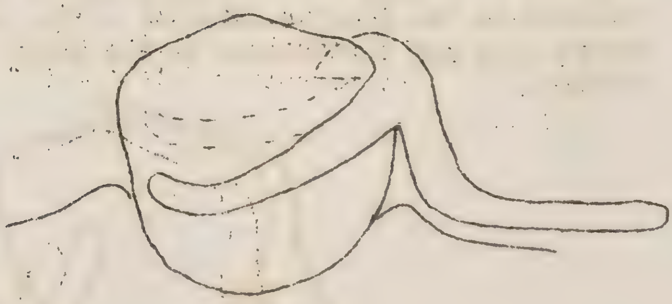
FIG. 2



Three Arm

Clasp

FIG. 3



Steps in Assembled Partial Denture Construction

1. Premlinary Impression by Dental Officer

   In partial work this preliminary impression is often taken using a hydrocolloid material. This is an accurate model for study.

2. Study Model

   Partial Denture study models are poured in Plater of Paris.

3. Outline of Partial Preparation of Teeth, Final Hydrocolloid Impression and Bite by Dental Officer

   After careful study, the Dental Officer outlines the partial denture on study models, and marks position of clasps, bar etc. From this model he prepares teeth where occlusal rests are indicated, by grinding the marginal ridges and then takes the final hydrocolloid impression.

4. Master Model

   This model is always poured in quick setting stone.

5. Survey, Design and Outline

   This step is usually done by the Dental Officer, but if not the method of surveying and a knowledge of proper design is essential if the partial denture is to function satisfactorily. The mechanical surveyor accomplishes this part of the technique best when used, but in its absence the case may be surveyed using a lead pencil and the eye. The cast is placed on the movable table of the surveyor and tilted to a position to provide favourable undercut conditions for construction of satisfactory clasps relative to the path of insertion, balance and retention.

   The teeth which have been selected for clasping are generally those which when clasped, neutralize leverage or tipping forces which operate during the functioning of the appliance.

   The teeth to be clasped are moved around the perpendicular carbon arm of the surveyor while in contact. The line thus inscribed on the teeth is called the relative height of contour. The next procedure is the designing or outlining in pencil on the teeth the clasp forms.

(a) Position of a clasp. The body of the clasp is on or above relative height of contour, while the arms are placed below as shown in Figure 1.

(b) Design of Clasps

1. Ordinary 3 arm clasp. Used when the long axis of the teeth being clasped are almost parallel and the bell of the teeth themselves is not sufficient enough to indicate the need for a more complicated design.

2. Roach design clasp. Used when the long axis of the tooth is on a severe angle and its shape is such that the ordinary three-arm clasp would not allow the case to seat itself properly in the mouth.

6. Clasp Construction

(a) Contouring wrought clasps (Wire Clasps). The correct method to bend wire clasps is to begin at the lingual arm and hold the completed portion of the clasp on the tooth. Mark and study for the next bend. This is repeated by continued bends and fittings until the clasp is finished. Most clasp wires come from the manufacturer already annealed but it is advisable to reanneal them. Often it is best to repeat this process several times during the bending as excessive bending will return the temper to the clasp wire. Annealing technique given in Part 1, Pages 20 and 21.

(b) When a third arm or occlusal rest is used a piece of 24 Karat, 36 Gauge gold plate, 3 mm. wide, 5 mm. long is burnished into the occlusal embrasure, prepared by the Dental Officer, and extended down the axial surface to a point beyond the body of the clasp. The clasp is then replaced holding the adapted gold occlusal rest in place. The rest is then reinforced by a piece of clasp wire of sufficient length to provide a free end to be imbedded in the investment. The parts are waxed together with sticky wax, removed from the tooth, invested in Crown and Bridge investment and soldered.

(c) Lug construction. Flattened wire is usually used in lug construction. It is adapted and attached to the body of the clasp in a position where it will not interfere with the placing of the teeth and does not

encroach on the area which will be occupied by lingual or palatal bars. It should also be adapted as close to the cast as possible. The usual length of lugs is approximately 10 mm. It is then waxed to the clasp, removed and soldered. After removal from the investment the assembled clasp is pickled, heat treated and polished.

7. Adapting Lingual Bar.

The technique of bending either palatal or lingual bars is similar to the clasp technique. Beginning on one side the work is carried on until completed on the other side. For position of bars. See Parts Connected Saddles Par. 3, Page 102.

Some Lingual bar material must be frequently annealed. The Lingual bar and clasp lug may be soldered together for additional strength. (Optional)

8. Steps in Assembly

(a) Adaptation of Base Plate (See previous techniques)

(b) Mounting in Articulator. Using the bite made by the Dental Officer (see Step 3) mount the casts in the articulator. The clasps and lingual or palatal bars are then set to position on the base plate and the metal occlusal rests ground in to permit the normal closing and articulation of the natural teeth.

(c) Setting the Teeth. The missing teeth of proper size and shade are selected and waxed into position. Articulation is perfected by grinding with suitable stones in practical cases.

Centrals, cuspids and bicuspids are frequently set in the arch omitting the facial flange. In such cases the teeth are placed directly against the tissue (cast) after making a suitable indentation on the cast to receive the necks of the teeth.

The assembled case is sent to the Dental Officer for try in.

9. Wax up and Investment

The case is waxed up similarly to the Full Denture technique.

Preparation for flasking. After removal of case from the articulator undercuts are relieved and the stone teeth trimmed off as follows. From the lingual wax border the trimming is inclined downward to the facial gingival line. Under clasps the stone teeth are trimmed about 1 mm. under occlusal rests and cut downward to a point below the clasp arms leaving them sufficiently free to be imbedded in the second investment.

Investment (Similar to full denture technique)

10. Curing, Finishing and Polishing

Similar to full denture technique.

Steps in Cast Skeleton Construction

1 to 5. These steps are the same as in the Assembled partial denture technique. The case is outlined on the master cast and all undercut areas are eliminated by building out with wax (hard).

6. Duplication of Models

(a) Materials and equipment

(1) Tin base, a lid from any plaster can 4 to 6 inches in diameter.

(2) Ring. This may be a large casting ring or one constructed using a tin can.

(3) Hydrocolloid material.

(4) Double boiler.

(b) Procedure of duplication: Place the ring on the tin base and seal in place by melting impression compound around the outside of the ring base. This not only holds the two parts together but keeps the hot hydrocolloid material from leaking out. Soak master model in water a few minutes. Place in the ring on the tin base. Hydrocolloid material is heated in the double boiler until it is a creamy consistency, add water if necessary. Place the ring in a pan containing enough cold water to cover the base and the compound. Begin pouring the hydrocolloid material slowly and in the center of the model. Fill the ring and cool until it is thoroughly jelled. Remove the model and pour up in model casting investment.

(c) Mount the master model on an articulator.

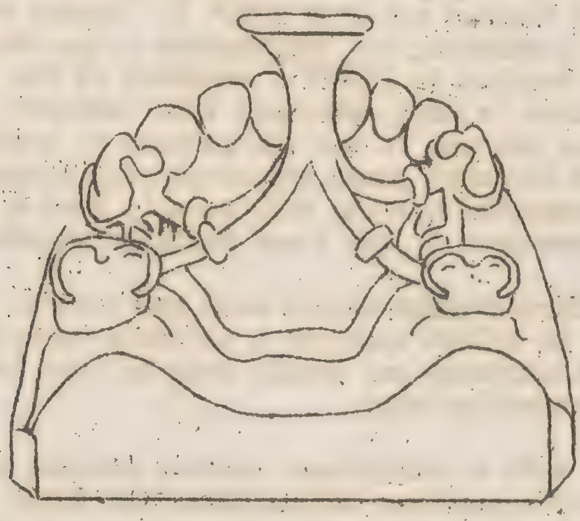
7. Waxing Design

After the investment model has completely dried, copy the design and the outline from the master model. Immerse the model in melted yellow beeswax for three minutes, remove and allow to cool and then begin waxing the case.

A few important points in waxing are:

(a) Be sure that the model is dry.
(b) Be sure the waxing is heavy enough to allow for finishing and polishing.
(c) Be sure the palatal and lingual bars are waxed heavy enough to allow for trimming of the proper relief.
(d) Be sure that all angles are rounded.

After the wax-up is checked by the supervisor or Dental Officer, the case is sprued. Use round wax sprues about 10 gauge and place the sprues at the heavy or bulky portions of the wax patterns. These sprues should be distributed so that the molten gold will flow to all parts of the case. It is usually not advisable to sprue at the center of a bar or on a clasp arm. Curved sprues prevent distortion of the case due to sprue shrinkage Castings can be made with one sprue, but additional sprues provide a factor of safety. Bring the sprues together at a point $\frac{1}{4}$" above the highest point of the casting. These sprues are waxed together to form one large lead sprue. Reservoirs can be placed on the sprues to safe-guard against trapped air and porosity.



To invest, use the same material that you used for the model and mix to the same creamy consistency. After the model has soaked in water 4 or 5 minutes, blow the excess water off and coat all of the wax surfaces with a $\frac{1}{4}$ to $\frac{1}{2}$ inch layer of your freshly prepared mix. Care should be taken in this step so as not to trap air and form bubbles. The use of a vibrator will act as a safe-guard against this.

After the painting mix has set, use another mix of model casting investment to invest the case in your casting ring. When this has set, place the ring in the casting machine and check to see if the large lead sprue centers with the crucible. Cut a funnel shape hole around the large lead sprue, and then the case is ready for the burning out process.

There are two methods of burning out a case, either of which can be most successfully used if proper attention is given to the necessary details and heat control. An electrically heated oven with pyrometer control is necessary to obtain uniform controlled heat together with uniform expansion of investment. The rapid elimination method develops a steam pressure, thereby washing out the wax, and often times disturbs the walls of the mold causing rough casting. The slow elimination method insures a smoother and more dense casting because of the carbonization process that takes place.

With this method the furnace is not permitted to go over the boiling point of water until the case is thoroughly dried out, or all free water has been eliminated through dehydration or volatilization and the investment has thoroughly absorbed the wax. This procedure will usually consume about one hour for a large case, and proportionately less as the size of the ring and bulk of investment is decreased. Following this process the temperature is gradually increased until it reaches not over 1300° F. Better results will be obtained by not permitting the temperature to go above 1200° F. If the temperature reached is 1300°F., maintain it for 30 minutes; and if 1200° F. maximum is used, maintain this temperature for 45 minutes. This heat soaking process is for the purpose of burning out any existing carbon. The occluded gases are presumably formed at or above 1200° F. The completed casting will usually have a cleaner and more gold colored appearance if the lower maximum temperature is used.

Under no circumstances should mere eye control for red color in a sprue hold be relied upon for a definite control of heat. This method is most inaccurate and should only be done in the absence of the pyrometer controlled heat.

In casting with a centrifugal casting machine you not only throw the gold into position but maintain the force a sufficient length of time to insure the solidification of the gold. The machine should be properly balanced with the casting in position before burning out. When the case burn out is completed, you wind the machine

3 to 7 times according to the spring tension and place the mold into position. Heat the gold in the least possible time and cast. The gold can be heated in the lined crucible before the flask is transferred from the oven. This will save time and will reduce danger of temperature reduction inside the mold.

Castings should normally be removed from the investment as soon as the temperature of the gold is less than 500° as shown by the color chart. Leaving castings too long in the investment after casting will produce a brittle appliance.

8. <u>Finishing and Polishing</u>

After all the plaster is removed from the casting, pickle the case by boiling in sulphuric acid (50% or nitric acid (50%). The casting should be pickled in hot acid rather than heating the casting and dropping it into the acid. The case is now ready for the removal of the sprues. These sprues and vents should be cut away with knife edge stones or discs. Under no circumstances should wire cutters be used as this leads to possible distortion of the casting.

Burs, mounted stones, rubber wheels, discs, felt wheels, tripoli and rouge are used in finishing and polishing. All exposed metal surfaces should be thoroughly polished. Rough, poorly polished areas tend to hold the saliva and cause any solid matter present to be deposited on the surface of the metal in much the same manner that calculus forms on natural teeth.

9. Just before the case has been given the final polish, it should be heat treated to give the metal its correct tempering or hardness and to restore the properties of the gold. This is done by placing the case in an oven that has been brought to a temperature of 842° F. and left for 15 minutes. The temperature is brought down slowly to 482° F. in 20 minutes. It is left at this temperature for ten minutes. Then the case is removed and plunged into water.

10. Final high polish.

The completion of the case from this point is the same as the Assembled Partial Denture technique, from Step 8 (Steps in Assembly) to 10.

CHAPTER IV

DUPLICATION AND REPRODUCTION OF DENTURES

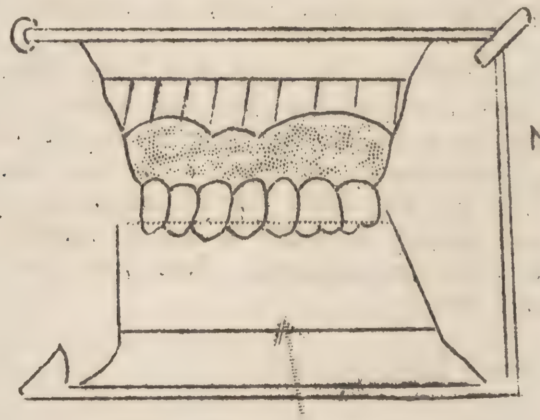
Frequently it is necessary to replace the entire denture base with new material. This procedure is referred to as reproduction, duplication, or jumping. There are several different methods or technics applicable to this procedure, but the articulator method and the template method are most commonly used.

1. Articulator Method (steps and procedure).

   a) An impression is taken by the Dental Officer, using the old denture as a tray.

   b) Impression is boxed and poured in stone.

   c) A matrix is made of the teeth in Plaster of Paris, with the teeth impressed to include all of the occlusal and incisal surfaces to a depth of one-third of the facial surfaces.



   d) The matrix and the denture is mounted on an articulator. Care should be taken that all parts of the articulator are tightened and the pin in its proper position.

   e) Open the articulator and remove the upper member. The teeth are then removed from the old denture base. This is accomplished by applying a thin layer of vaseline or wax over the teeth. Then pass the denture several times through a flame until the old

denture base material is soft enough to allow the teeth to be gently pressed free. The teeth are cleaned and arranged in their proper position in the matrix. They are secured to the matrix with sticky wax on the labial and buccal surfaces.

f) The old denture base is then carefully removed from the model. Enough heat is applied to insure its safe removal and it is pried loose.

g) The model and matrix are then placed back on the articulator and one layer of base plate wax adapted to the model as a base plate. A wax ridge is mounted on the base plate and softened with a hot spatula. Close the articulator gently until the pin is down and then wax the teeth to the ridge. This waxing should be heavy enough to hold the teeth in position without danger of their moving. The sticky wax is then freed from the labial and buccal surfaces and the articulator is opened.

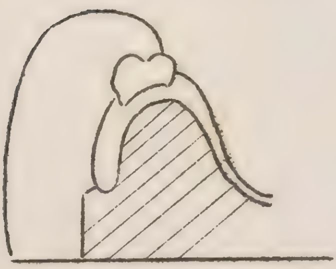
h) Wax up the denture and proceed as previously instructed under full denture technique.

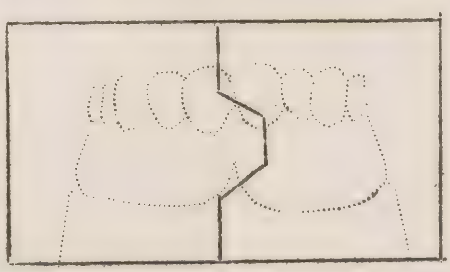
2. <u>Template Method</u>

a) An impression is taken by the Dental Officer, using the old denture as a tray.

b) Impression is boxed and poured in stone.

c) <u>Plaster of Paris Template</u>. Make several deep grooves on the buccal and labial surface of the base of the model. Lubricate the teeth and the buccal and labial surface of the denture and the model. Build a plaster index around the entire outer surface of the denture and model, extending the plaster to about one-fourth inch from the incisal and occlusal surface of the teeth. This index or template is prepared in two halves, the two interlocking to form the one template.





d) Remove the template.

e) Remove old denture from the model (same as 1.e. page 101).

f) Remove teeth from the denture (same as 1.f. page 101).

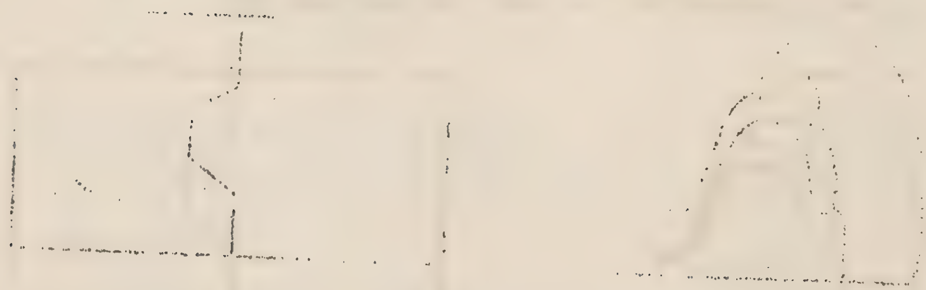
g) Clean the teeth, lubricate the template, arrange the teeth in their proper position in the template, and secure with sticky wax on the lingual surface.

h) Melted base plate wax is flowed into the space between the teeth and the model.

i) The sticky wax holding the teeth is removed as well as the template.

j) Proceed with waxing and finishing.

Of these two methods the articulator method is the more accurate because it has the advantage of using the matrix for additional checking after the case is waxed-up. The plaster matrix is trimmed so that just the incisal and occlusal surface is exposed; then by closing the articulator you have your final check. This matrix can be used again as a check after case has been finished.



CHAPTER V

REBASING AND REPAIRING DENTURES

Often the gums will shrink or pull away from the denture after it has been worn for some time. This causes the denture to become loose and irritating to the patient. If the denture is in good condition this discrepancy may be corrected by adding a new base or foundation of denture base material. The technician receives the new impression which has been taken in the old denture.

1. Steps for the rebasing procedure:

    a) Box the impression and pour in stone.

    b) Case is flasked, same as for a new denture.

    c) Separate the flask.

    d) The tissue surface of the old denture is roughened by vulcanite burs to facilitate the addition of the new denture base material. Sufficient material should be removed to allow for about 1 mm. of new denture base material.

    e) Case is packed, cured, and finished as previously instructe

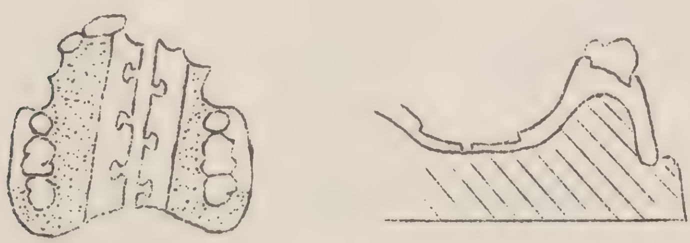
2. Simple Repair of Fractured Denture.

    a) Bring the fractured edges of the denture into apposition and seal them together with sticky wax. Pieces of stiff wire or match sticks are laid over the fractured denture at right angles to the line of fracture and waxed into place. This gives the denture additional support.

    b) Lubricate the tissue surface.

    c) Pour a cast using such material as may be directed by the Dental Officer.

    d) When the cast has set, remove the denture parts. Using abrasive chucks and vulcanite burs, grind away a large portion of the denture on each side of the fracture. This preparation may be dovetailed as shown in the following diagram:



e) Replace the fractured parts on the cast and fill in the missing space with base plate wax. Make this wax a little thicker than the original denture. This will allow for finishing and polishing.

f) Flask the case in the lower half so that only the wax portion is exposed.

g) Pour upper part of flask.

h) Separate, pack, cure, and finish as previously instructed

3. <u>Loose or Broken Teeth</u>

a) When an original tooth has become loosened and can be replaced, it is only necessary to make certain that it fits in its exact position as marked on the denture. Then cut a dovetail in the lingual or palatal surface of the denture adjacent to the tooth, replace the tooth in its original position, and secure it with wax. The case is then carried forward as for a simple repair.

b) When the tooth has been broken or lost and a new tooth is necessary, but the denture base at the site of the tooth is intact, it is necessary for the Dental Officer to supply the technician with a wax bite indicating the relationship of the teeth of the opposing jaw. Fit the teeth of the denture into the depression on the bite, and seal it to the denture. Fill the depression left in the bite by the teeth of the opposing jaw with plaster. Mount the denture and bite on a hinge or plain articulator. Remove the bite and place the new tooth in the correct position. Do not grind away any of the denture base material from around the neck of the tooth, but do all necessary grinding on the tooth itself. Wax into position and proceed as for a simple repair.

4. <u>Loose Clasp Repair</u>

The Dental Officer has taken an impression of the clasped tooth with clasp and denture in position. The impression is poured as directed and the denture base material is cut out from around the connector of the clasp. This area is filled with wax and carried to completion as a simple repair.

CHAPTER VI

CONSTRUCTION OF CROWNS

Crowns are substitutes for the lost enamel of a tooth. They are usually classified as:

(1) Cast crowns.

(2) Gold shell crowns.

(3) Seamless crowns.

(4) Richmond crowns. (7. Acrylic)

(5) Davis crowns.

(6) Porcelain jacket crowns.

I. Cast Crowns

In general there are two types of cast crowns; namely, full veneer crowns and partial veneer crowns. A full veneer crown replaces 5 surfaces of a tooth while a partial veneer crown, most always, replaces all surfaces except the facial surface, and is used most generally in anterior teeth.

There are three fundamental methods which are used in the construction of cast crowns. They are

(1) Direct method.

(2) Indirect method.

(3) Indirect-direct method.

In the Direct Method, the technic which is followed is carried out mainly by a Dental Officer so it is not necessary to explain it in detail.

1. All of the enamel of the crown of the tooth is removed by means of burs and stones.

2. A copper matrix is fitted around the tooth and softened wax is pressed into the matrix. After the wax is cooled the matrix is slit and removed. The crown is then carved into occlusion and to the anatomical shape of the tooth being crowned.

3. The pattern is sprued and removed.

4. Invest the pattern (carried from here on by the Laboratory)

5. Burn out the wax.

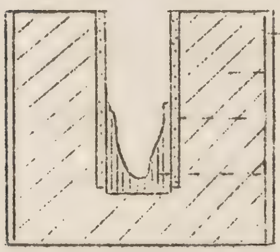
6. Cast.

7. Polish the occlusal surfaces, and the axial surfaces down to about 2 mm from the margin if you are told to do so by the Dental Officer.

In the Indirect Method the Dental Officer will prepare the crown in the same manner, adapt a copper matrix and then take an impression with compound. It is then turned over to the laboratory where the following steps will be carried out.

1. Impression. The impression of the crown preparation will be washed with soap and water and will be boxed so that a die may be packed in it. A strip of base plate wax may be wrapped around the matrix and sealed. Gum paper may be substituted for the wax and will serve the purpose very nicely.

2. A rubber ring or casting ring is lubricated with vaseline and soft plaster is poured into it. The boxed impression is then pressed into the plaster. Be careful not to allow the plaster to overflow into the impression.



3. Dies. These are packed in either amalgam, Kryptex, artificial stone or materials such as Kerr's dialite. After setting they are trimmed and soaked in lubricating oil. Amalgam dies must be allowed to set for a period of over 12 hours. If the work must be hurried, Kryptex or stone dies should be used, in which case we do not invest the impression in plaster but pour directly into the boxed impression.

4. Wax Pattern. The wax is melted in a spatula and applied to the die. The wax pattern is carved on the die to resemble the anatomical form of the lost tooth structure. It is removed from the die, sprued and made ready to be cast.

5. Casting. The wax pattern is invested in casting investment as was done in the inlay casting technic. The wax is burned out in the electric furnace and the casting made in gold.

6. Finishing. The crown is finished and polished similarly to the method used in polishing inlays.

The main objection to the use of this method as it is outlined above is that we have little or no idea of the manner in which the crown is to occlude with the opposing teeth. Its main object is to cut down on the time which the patient has to be in the dental chair, coupled with the fact that the work can be done in one's spare time.

These objections can be overcome by the use of the Indirect-Direct Technic. This technic utilizes all of the advantages of the indirect technic and also allows us to check on the occlusion and articulation of the crown.

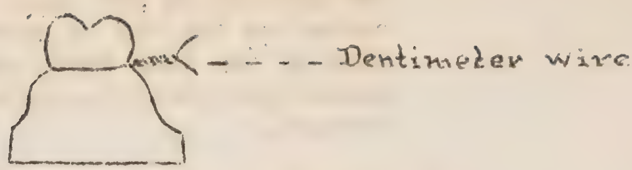
All of the steps of the indirect method are carried out up to and including the carving of the wax pattern. At this point we switch over to the direct method, and try the pattern in the mouth. We must then make the required changes in the wax pattern after which we sprue, invest and cast as in our inlay technic.

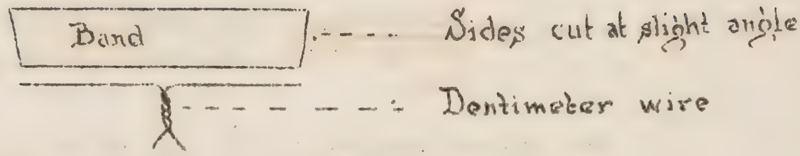
II. Gold Shell Crown

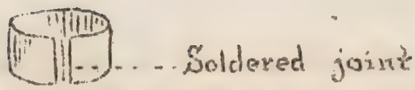
This crown is a less costly type of crown and can be constructed more quickly than a cast crown. This crown is also known as a two-piece crown. It may have either a cast occlusal surface or a swagered occlusal surface. The technic is as follows:

1. The Dental Officer has prepared the tooth.

2. Cutting Band from Dentimeter Measurement. The circumference of the crown preparation is measured by the dentist by means of an instrument known as the "dentimeter". This step can be carried out either directly in the mouth or by the indirect method using a die. The band is cut as shown in the diagram. It is then contoured and the two edges soldered together. This is presented to the dentist for fitting to the prepared tooth.





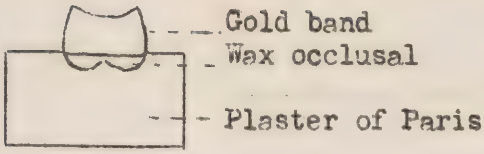


Band Contoured

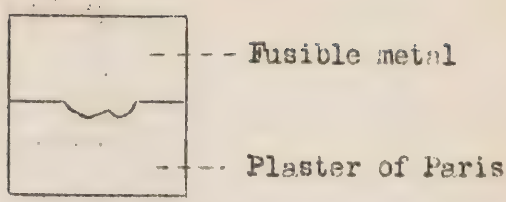
3. The band is contoured to insure the proper shape by the Dental Officer and then we use one of the two types of occlusal surfaces.

    (a) Cast Occlusal Surface - The dentist will carve an occlusal surface and it will be presented to the laboratory, seared to the gold band. The pattern and band will be invested and a casting made.

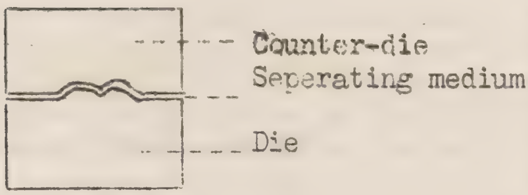
    (b) Swaged Occlusal Surface - In this method a die and counter-die are made from the wax pattern of the occlusal surface and a piece of 36 gauge gold plate is swaged between them. It is trimmed to fit the gold band.



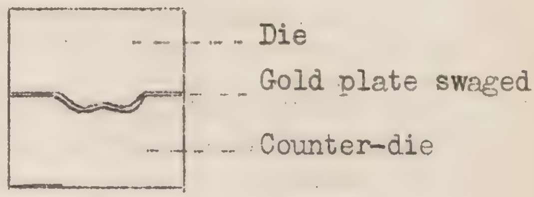
Occlusal Surface
Invested in plaster Mold.



Die Poured into Plaster
Mold.



Counter-die Poured
Against Die.

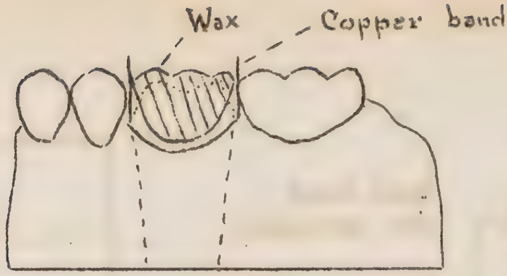


Gold Plate Swaged between Die
and Counter-die.

4. Soldering of the Crown. The occlusal surface is soldered to the gold band so that there is a complete seal.

5. Finishing and Polishing of the Crown. This is accomplished similarly to the method used in finishing the cast crown.

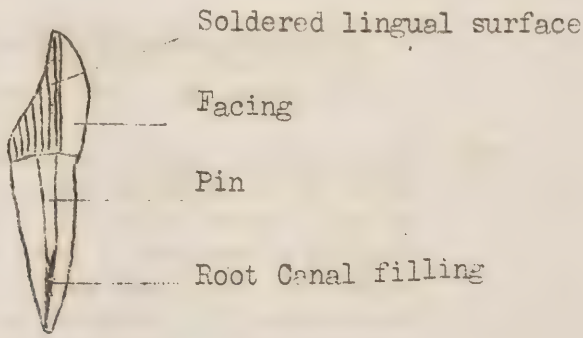
III. The Seamless Crown is probably the most common crown that is being used although unless it is perfect it probably is one of the poorest types of restoration. This crown is made by swaging a commercial gold thimble over a Melotte's metal die which has been made smaller than the finished crown. The dimensions are governed by the thickness of the gold thimble. A copper band matrix of the same gauge as the gold thimble may be used to determine this.



Inlay wax is then added and carved into the desired size, shape and occlusion. A split mold is then made of the tooth which has been sawed out of the model and a die is poured in a low fusing metal. The thimble is then adapted to the die and swaged. The die metal is then removed by heating either in a direct flame or by boiling in water.

The crown is cleaned and pickled by placing it in acid and washing it with water. Do not heat the crown before placing it in acid. It is trimmed to the gingival markings and a small amount of solder is allowed to flow into the crown to act as reenforcement for cuspal wear.

IV. Richmond Crown is a crown that is seldom made. It consists of a pin, facing, gold coping and solder. The procedure is as follows: A pin is inserted in the pulp canal of a devitalized tooth. A piece of gold coping is adapted to the facing and root of the tooth and sticky waxed together so as to be able to withdraw the parts in apposition to one another. The case is then placed in soldering investment and solder flowed to form the lingual surface of the tooth. It is then ground to the desired shape and polished.



V. The Davis Crown is another type of pin and dowel crown. A porcelain crown tooth is ground to fit the root preparation and is cemented into place. The pin being used for the purpose of retention.

VI, Porcelain Jacket Crown. This crown is very commonly used in civil life but seldom used in the army. The main purpose of this type of crown is to fulfill the requirement of esthetics. The shades of porcelain may be mixed in such proportions as to match any shade of natural teeth.

Since it is not used in the army we will not give any detailed method of construction. It will suffice to say that a thin platinum foil is adapted over a die of the prepared tooth. The porcelain powder is moistened and placed over the platinum matrix and carved into the desired shape. It is then placed into a porcelain furnace and baked.

CHAPTER VII

CONSTRUCTION OF BRIDGES

A bridge is an appliance used to replace one or more lost natural teeth. They are usually classified as:

(1) Fixed
(2) Movable
(3) Movable-removable
(4) Removable

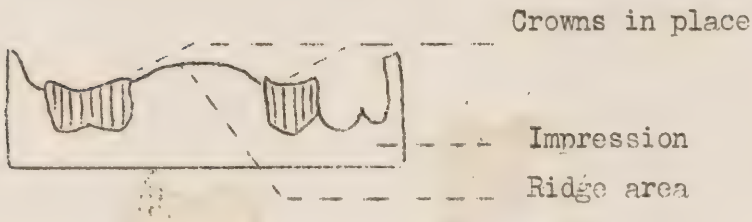
I. Construction of a Fixed Bridge

The fixed bridge differs from a partial denture in that once it is cemented into place, it is not removed by the patient, and hence is termed "fixed bridgework". Abutments for fixed bridges are, in general, cast crowns, gold shell crowns, or inlays.

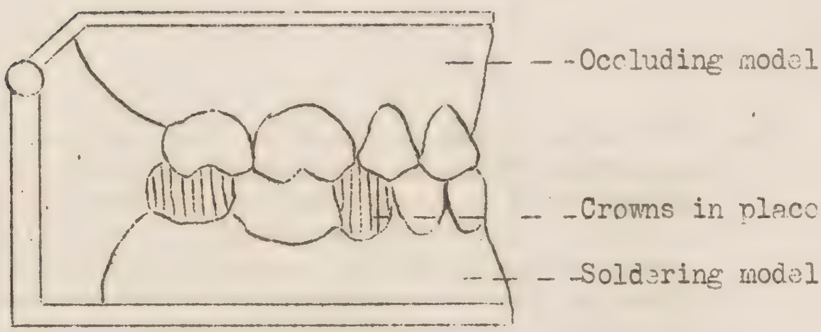
An abutment is defined as the terminal of a bridge which receives the stress of an arch. The pontic is commonly known as the "dummy" or as a "space filler". They are comparable to the span of a bridge.

1. The abutments have been cast, finished and placed in the mouth by the Dental Officer who then takes a plaster impression of the area to be bridged and opposing teeth. A wax bite must also be taken to insure proper relationship of the jaws when the case is mounted. The abutments are usually removed in the impression but if not, they are placed in the impression and seared into position. The impression is then painted with a staining and separating fluid, and poured in a refractory investment (heat resisting such as Cristobalite (model) or crown and bridge investment). The impression of the opposing jaw is poured in stone or metal. When the material has set the models are separated and mounted on an articulator using the wax bite if necessary.

IMPRESSION WITH CROWNS IN PLACE

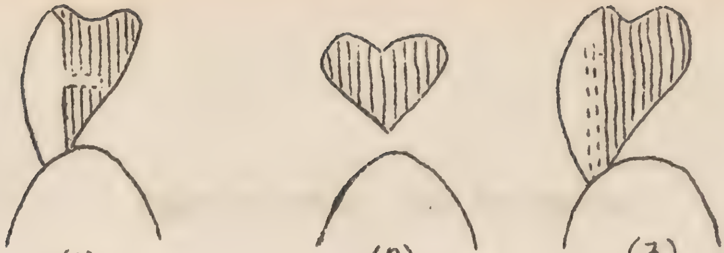


MOUNTED ON THE ARTICULATOR

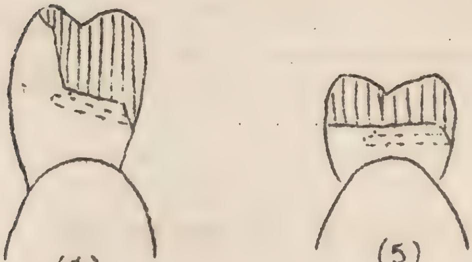


The case is ready for the construction of the pontic of which there are several types,

(1) Long pin facing.
(2) Sanitary gold pontic.
(3) Steel's facing.
(4) Steel's tru pontic.
(5) Steel's Santi-pontic.

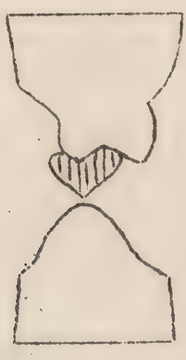


(1) (2) (3)



(4) (5)

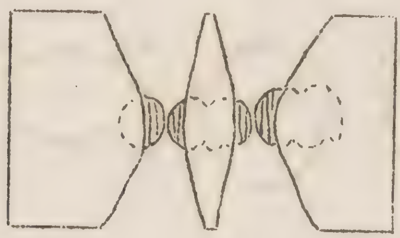
2. The pontic which we shall use for our lower posterior bridge is the Sanitary pontic. A wax pattern will be carved between the two abutments so that it is in occlusion with the opposing teeth andconverging to a point at the gingival tissues. The Bucco-lingual width of the pontic should not exceed 4/5 of the natural width of the tooth being replaced. The purpose of this is to reduce the biting stress or amount of pressure exerted upon the abutment teeth which are carrying the extra load. The amount of pressure or stress may run up to a maximum of 340 pounds per square inch.



The other type of pontics, namely, porcelain tips and porcelain facings are ground to fit the bridge and buccal tissue surface and so that it will not be displaced by occlusion and the wax pattern carved to fit these. The stress of mastication is then on the gold occlusal instead of the porcelain.

3. Investing and Casting. The wax pattern is removed from the soldering model, invested, burned out, and cast. It is trimmed, and finished but not polished.

4. Soldering the Bridge.- The pontic is placed back on the soldering model so that it is in its proper position. The model is soaked in water and a small amount of soldering investment is placed around the pontic so that it will be held in place on the soldering model. After this is allowed to set, the model is placed over a Bunsen burner flame and the pontic soldered to the abutments, using a soldering torch.

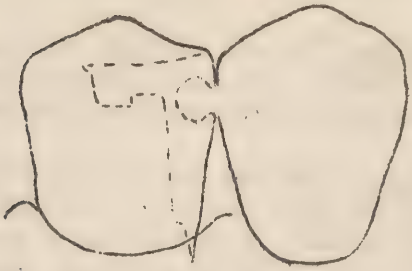


5. Finishing and Polishing of the Bridge. - This is accomplished with sand paper, discs, pumice, and chalk. It is now ready for cementing by the Dental Officer.

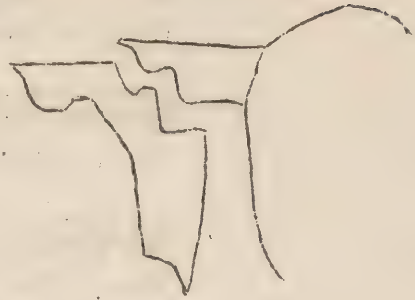
II. Movable Bridges

Due to the fact that our teeth are grouped functionally as, incisors, prehensile, pre-masticating and masticating teeth we often do not wish to combine two or more groups in one continuous bridge. For example; a bridge replacing molars and a second bicuspid would combine two functional groups. These groups may be segregated by cementing one end of the bridge and fixing it and allowing the other end rest on the abutment.

These rests may take the form of a ball and socket joint, an occlusal rest or inlay within an inlay.

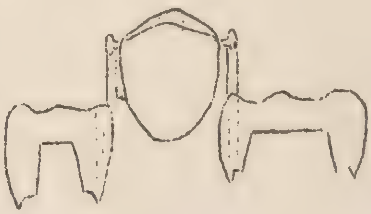


Ball and socket



Inlay within an inlay

III. A movable removable bridge is one which has two fixed abutments and the pontics rest in prefabricated attachments.



IV. The removable bridge has been discussed in the chapter on partial dentures. There has been much confusion as to the definition of partial denture and removable bridge. The army classifies the replacement of lost natural teeth according to whether or not any stress is borne by the tissue. If there is no stress on the tissue the appliance is classified as a bridge. If any or all stress is on the tissue we have a partial denture.

CHAPTER VIII

SPLINTS

The use of Splints are very important in the Army Dental Service. In warfare, injuries to the face and jaws frequently occur; so it is important, as dental technicians, to have a thorough knowledge of their construction and application.

A splint is a mechanical appliance constructed to immobilize and retain segments of a fractured jaw in position until the bone has united. It must be understood that no two cases will be the same or will use exactly the same design of splint, but they are sufficiently similar to follow the same basic principals of design and construction. The following design can be used for either maxillary or mandibular splints and can be constructed of --

1. Vulcanite.
2. Acrylic.
3. Cast silver.
4. 18 gauge wire (arch wire)

The preparatory work in the construction is the taking of an impression of the fractured jaw. This impression is poured in stone. The fragments are usually outlined by the Dental Officer and sawed free of the model. These sections are re-assembled to the correct occlusion and normal position. Sticky wax and supporting rods are used to maintain these sections in position while adding a new base.

I. VULCANITE SPLINT

1. The prepared model will come to the laboratory for the construction of the splint.

2. The designing will be done by the Dental Officer on the model. To obtain the maximum of efficiency the designing of this type of splint will incorporate the following principles:

   a. The splint should cover all free gingival Margins on the lingual, buccal, and labial surfaces -- at least two or three millimeters from the necks of the teeth.

   b. The splint must cover the cervical two-thirds of the teeth and must include as much of the occlusal third as possible without interfering with the masticatory processes.

3. A piece of 14 gauge half round wire is bent to conform to the distal surface of the last molar tooth. It extends forward on both the lingual and buccal surfaces of the tooth

almost to the mesial surface. At this forward point the wire should be bent at right angles and extending about one half an inch away from the tooth. These two projections of wire, along with that portion around the distal of the tooth, will be imbedded in the plaster during the flasking process, thus holding the wire in its correct position.

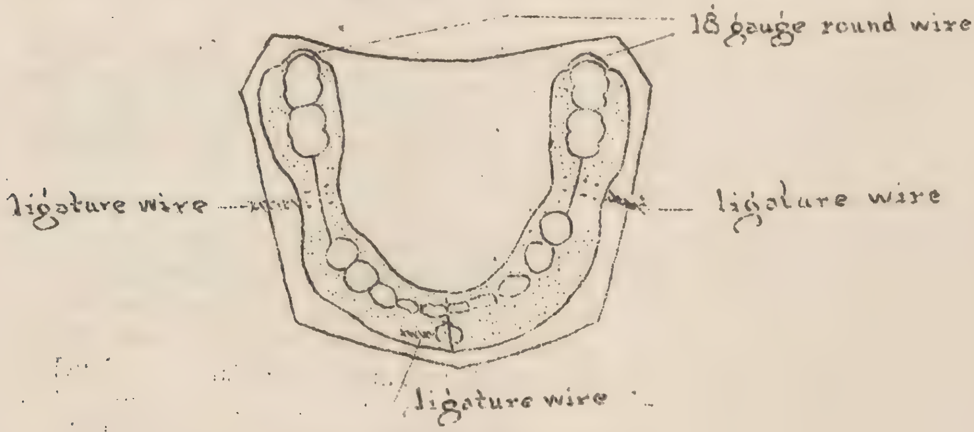
4. Cover the design of the splint with a thin coating of sticky wax and place the prepared distal wires into position. Make certain that wax is in all the interproximal spaces.

5. Soften a piece of baseplate wax and fold it over on its self, making a double thickness. Adapt this over the wax already in place, on both lingual and buccal surfaces of the cast. Trim the wax to conform with the design of the splint.

6. Make a small button on the labial surface of the wax pattern at the median line. This small disc or button will be used to secure the finished splint in place in the mouth.

7. All edges of the wax must be sealed to the model.

8. Chill the wax, flush with a flame, and polish.



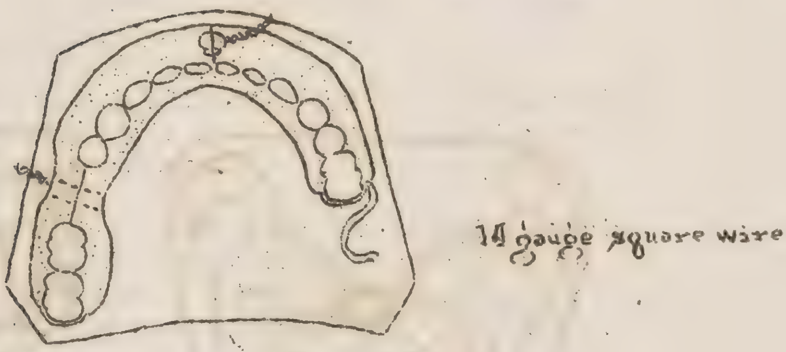
9. In some fractures, it is necessary to design the case so that a loose or broken fragment of the bone in an edentulous area, may be held in place. This is accomplished by constructing projections of wire which extend out from the splint and hold these fragments in place. A piece of nickel tubing 10 x 14

gauge is incorporated into the splint by soldering it to the buccal surface of the half round wire, so that it will be parallel to the buccal surface of the teeth. A piece of 14 gauge square wire is inserted into the tubing and the other end is bent so that it will rest on the buccal tissue over the fragment requiring stabalization.

10. The wax is melted around the nickel tubing so that it is flush with the surface of the wax pattern.

11. The case is now ready for flasking. Trim off all of the occlusal surfaces of the teeth flush with the wax pattern. Invest, pack, and cure as previously instructed.

12. In every space where there is a tooth missing the buccal and lingual parts of the splint are drilled with a bur and separated by sawing. The button in the median line is also sawed vertically in half. Thus the splint is in two parts connected by the distal wire. This can be placed in the mouth, brought into position and the two halves of the button wired together. A piece of brass ligature wire is used for this purpose.



II ACRYLIC SPLINT

The construction of a splint, using acrylic resin material in place of vulcanite, is the same as described for vulcanite with the exception that the wax pattern and the model are tin foiled. This follows the procedure previously instructed under full denture. The use of the clear acrylic allows the Dental Officer to observe the condition of the teeth and gums underlying the splint. In using clear acrylic it is a good plan to pack with a Tarno or stainless steel instrument instead of using the fingers.

III CAST SILVER SPLINTS

1. Prepare a duplicate model of model investment compound.

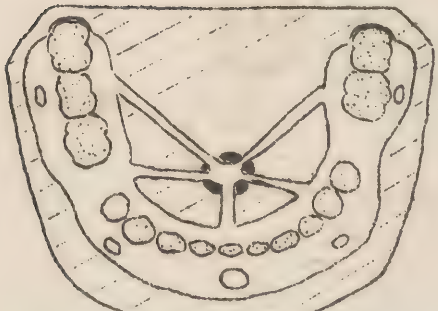
2. The design and waxing follows the same procedure as given under vulcanite splints with the exception of that only one thickness of base plate wax instead of two is used.

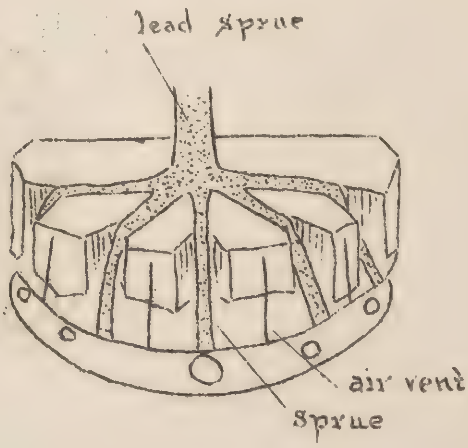
3. The 14 gauge wire is used in the same manner.

4. The button in the median line is the same, but we add four small buttons to the wax pattern. One is placed in each of the cuspid areas and first molar areas.

5. Smooth and polish the wax pattern.

6. There are various ways of sprueing and the following diagrams illustrate a very satisfactory method.





Cut a hole through the center of the model about the size of a dime. On the inner lingual surface of thepattern are attached five small sprues (about 12 gauge). On the buccal surface cut 5 grooves that slope toward the central sprue and attach five more sprues. Air vent sprues may be attached to pattern stopping at the edge of the model. Invest according to instructions in Partial Denture chapter, pages 97 and 98.

IV <u>18 GAUGE ARCH WIRE SPLINT</u>

1. The prepared model will come to the laboratory for construction of the splint.

2. The designing will be done by the Dental Officer.

3. Refer to technic previously given in Chapter III on annealing of wire. In this the preparation of the clasp wire is the same and the initial bending begining at the mesial lingual surface of the last molar on one side is the same. From this point you continue the adaption of the arch wire following the outline and finish the bending at the mesio-lingual surface of the last molar on the opposite side of the mouth. Care should be taken to adapt the wire as closely as possible in the interproximal spaces.

4. Sticky wax small pieces of 18 gauge wire perpendicular to the arch wire at the various markings on the model. These pieces should be approximately $\frac{1}{4}$ of inch in length.

5. Remove the wire, invest and solder.

6. Heat treat the arch wire to obtain its maximum strength and efficiency.

7. Polish.

PART IV

APPENDIX

Dental reports, returns and records

I. Dental history - a monthly compilation of records of dental activities of the station and command.

1. It consists of monthly report of dental service (Form 57 M. D.)

2. Statement of expenditures of special dental materials. (Form 18B M.D.)

3. Reports of dental opinions on clinics.

4. Schedules of instruction for enlisted assistants.

5. Memoranda recommended for incorporation in sanitary orders.

6. Special reports and articles for publication.

7. Such other data as are deemed pertinent.

II. Monthly Reports

1. Monthly reports are required monthly from every military station and separate command where a Dental Officer has been on duty during the month. This report is rendered on Form 57 M.D. It includes in brief;

   a. Station or command, location, date and period covered.

   b. All stations and command from which patients were regularly drawn.

   c. Total number of admissions for routine treatment.

   d. Total number of administrations for emergency treatment.

   e. Total number of sittings.

   f. Initial classification, additional and changes in classification. Total of each.

   g. Diagnosis made; operations performed.

   h. Number of Dental Officers on duty - total days of duty.

   i. Name, grade, special qualification, etc., of every enlisted man on duty in the dental clinic.

   j. Remarks.

2. Statement of expenditures of special dental materials (Form 18B M.D.) This report is required from any dental clinic where laboratory facilities are available and a Dental Officer is present. This report must be forwarded monthly whether or not special materials have been used. This report is also known as the "Gold report". It consists of the name and status of the persons for whom expenditure is made, appliances used and amounts of special materials used in each case. Amounts of special dental materials on hand, last report, amounts received, amounts expended, amounts remaining on hand at the close of the period will be entered together with suitable remarks.

At this station five copies are made one for each of the following:

1. Surgeon General.
2. Corps Area.
3. Commanding officer of the Post.
4. Medical supply.
5. Retained by the department.

The report must be forwarded through medical channels before the 5th of the next succeeding month.

3. Register of dental patients (Form 79 M.D.). For our purposes it suffices to say that this form or register is a case record. All register cards of patients whose cases are not closed (still under treatment) are filed in the Current file. When the case is finished the card is filed in the Permanent file.

4. Special Reports on Form 79 M.D.

   a. When a patient is confined to quarters or hospital as a result of dental conditions, the dental surgeon will furnish the surgeon with a duplicate of the patient's case record, Form 79 M.D.

   b. Form 79 M.D. is also used for incorporation in the patient's clinical record after he has been referred to the dental clinic by a medical officer.

PROPERTY

EXPENDABLE PROPERTY is that property which is normally consumed by its use, such as fuel, stationary, waxes, burs, and similar items; or which by its use becomes an integral part of other property, such as repair parts for chairs, the dental unit is non-expendable but the glass cuspidor is expendable. Some other items which are not expensive, and which are not very durable, being easily broken or quickly worn out through no fault or neglect on the part of anyone concerned, are also considered expendable.

NON EXPENDABLE PROPERTY is any property that is not considered expendable as defined.

REQUISITION is a request to the Property officer or to the proper Supply for supplies or materials needed.

MEMORANDUM RECEIPT is a record or receipt for articles issued (Debit Memorandum Receipt) or turned in (Credit Memorandum Receipt).

There are two types of forms that are used: the Medical Department, U. S. Army and the local forms. At Letterman General Hospital we use the following forms in dealing with property:

Form #2 Letterman General Hospital is a local form and is comparable to Form 16a M.D., U. S. Army. It is an issue slip for Expendable Medical Property. This form is filled out with the item number, name of article as stated in the Supply Catalog, quantities on hand and the number of items of each that are requested. This slip is signed by the officer in charge and is turned in to the supply depot where the supplies will be picked up in due time. This form is filled out in the original and no duplicate is necessary.

Form 16b M.D., U. S. Army is a blue issue slip that is used in obtaining non-expendable property. It is filled out using the same principles as in Form #2 Letterman General Hospital with the exception that it is filled in duplicate. The duplicate is kept by department requesting the supplies.

Form 16c M.D., U. S. Army is a pink credit slip for non-expendable property. It is made in duplicate and is used to obtain credit when non-expendable items are returned to supply. It relieves the officer in charge of the property, of the responsibility for those items which appear upon this form.

Form 16 d M.D., U. S. Army is a yellow slip filled in duplicate. It is used as an exchange slip for non-expendable medical property. This includes articles that are non-expendable, which are broken and are to be exchanged for items which are in good condition. If a broken item is to be turned in and supply is out of this particular item a credit slip may be used and a new item drawn out on form 16b when these items are again in supply.

Form No. 94 Letterman General Hospital is a local form that is used as a request for the Purchase of Non Standard Medical Supplies. These items must be approved of by the Commanding Officer. Any item that is not or has no equivalent on the Standard Medical Supply table, but which is necessary in the treatment of patients or for teaching purposes, as in our case, may be purchased from the open market.

Form No. 95 Letterman General Hospital is a white Monthly Overage and Shortage Report which is filled out at the end of each month after inventory has been made of the stock and supplies. A survey may or may not be held depending upon the amount of the shortage and approval by the Commanding Officer.

ABBREVIATIONS AUTHORIZED.--To effect economy of space and insure uniformity of records, abbreviated entries are authorized as indicated in the following tables:

a. Designation of the teeth.

1--Superior central incisors.	9--Inferior central incisors.
2--Superior lateral incisors.	10--Inferior lateral incisors.
3--Superior cuspids.	11--Inferior cuspids.
4--Superior first bicuspids.	12--Inferior first bicuspids.
5--Superior second bicuspids.	13--Inferior second bicuspids.
6--Superior first molars.	14--Inferior first molars.
7--Superior second molars.	15--Inferior second molars.
8--Superior third molars.	16--Inferior third molars.

The letters R and L will be used to indicate whether the tooth is on the right or left side of the dental arch. These letters will immediately precede the tooth number when the latter is designated, e.g., R6 would indicate superior right first molar.

b. Abbreviations for tooth surfaces.

m--Mesial	d--Distal
i--Incisal	f--Facial
o--Occlusal	l--Lingual

When more than one tooth surface is involved a combination of the abbreviating letters will be used, e. g., mo=mesio-occlusal; do=disto-occlusal; mod=mesio-occlusio-distal; fo=facio-occlusal; lo=lingo-occlusal; fod=facio-occlusio-distal, etc.

c. Abbreviations for filling operations.

A--Amalgam filling	Inl--Inlay filling.
G--Gold filling.	O--Oxyphosphate filling.
G--P--Gutta-percha filling.	S--Silicate filling.

When two or more materials are used in a filling operation the two or more abbreviating letters will be used, e.g., OA=Oxyphosphate and amalgam.

d. Other Abbreviations.

AInc--Abscess, incision of.
Alvcty--Alveolectomy.
AnesCn--Anesthesia, conductive.
AnesGn--Anesthesia, general.
AnesIn--Anesthesia, infiltrative.
AnesPr--Anesthesia, pressure.
Apicty--Apicoectomy.
B/1--Bar, one (other numbers may be used as B/2, bar two,etc).
BdgFx--Bridge, fixed. (A partial artificial denture retained by crowns or inlays cemented to natural teeth which are used as abutments.)

BdgRm--Bridge, removable. (A partial artificial denture retained by attachments which permit of the removal of the denture, and in this case the stress of mastication is borne entirely by the abutment natural teeth.)

Cwn--Crown artificial

CR--Calculus, removal of.

C/1--Clasp, one (other numbers may be used as C/2, clasp, two, etc.).

Dtr--Denture, artificial. (An artificial denture replacing all natural teeth of either jaw except the third molars.)

DtrPr--Denture, artificial, partial. (A partial artificial denture, which is removable and in this case the stress of mastication is borne entirely by the alveolar ridge or may be distributed between the ridge and supporting natural teeth.)

GT--Gingiva, treatment of.

G--AD--Gingiva-alveolus, debridement of.

G--AT--Gingiva-alveolus, treatment of.

POT--Post operative treatment.

Prlx--Prophylaxis.

PE--Pulp, extirpation of.

Rctd--Reconstructed.

Rpd--Repaired.

RF--Root canal, filling of.

TE--Tooth, extraction of.

TT--Tooth, treatment of.

CHAPTER IV

WEIGHTS AND MEASURES

The metric system according to Webster is a decimal system of weights and measures originating in France at the close of the 18th Century. The basis for the metric system was intended to be and is very nearly one ten-millionth part of the distance measured on a meridian of the earth from the equator to the pole.

METRIC SYSTEM OF MEASURES AND WEIGHTS

Linear

The Unit of Length is the Meter (M)

				Abbreviation
10000	meters	=	one Myriameter	(Mm)
1000	meters	=	one Kilometer	(Km)
100	meters	=	one Hektometer	(Hm)
10	meters	=	one Dekameter	(Dm)
1	meter	=		(M)
.1	meter	=	one Decimeter	(dm)
.01	meter	=	one Centimeter	(cm)
.001	meter	=	one Millimeter	(mm)

Volume

The Unit of Volume is the Liter (L)

				Abbreviation
10000	liters	=	one Myrialiter	(Ml)
1000	liters	=	one Kiloliter	(Kl)
100	liters	=	one Hektoliter	(Hl)
10	liters	=	one Dekaliter	(Dl)
1	liter	=		(L)
.1	liter	=	one Deciliter	(dl)
.01	liter	=	one Centiliter	(cl)
.001	liter	=	one Milliliter or Cubic Centimeter	(mil or cc)

Weight

The Unit of Weight is the Gram (Gm)

				Abbreviation
10000	grams	=	one Myriagram	(Mg)
1000	grams	=	one Kilogram	(Kg or Kilo)
100	grams	=	one Hektogram	(Hg)
10	grams	=	one Dekagram	(Dg)
1	gram	=		(Gm)
.1	gram	=	one Decigram	(dg)
.01	gram	=	one Centigram	(cg)
.001	gram	=	one Milligram	(mg)

U. S. SYSTEM OF MEASURES AND WEIGHTS

Linear

1 link	(li)	=	7.92 inches	
1 foot	(ft)	=	12 inches	
1 yard	(yd)	=	36 inches	
1 rod	(rd)	=	198 inches	= 25 links
1 chain	(ch)	=	792 inches	= 100 links
1 mile	(mi)	=	5280 feet	= 1760 yards

Volume

(Liquid Measure)

1 minim (min. or M)	=	0.01667 fluid dram
1 fluid dram (fl. dr.)	=	0.125 (1/8) fluid ounce
1 fluid ounce (fl. oz.)	=	480 minims
1 fluid ounce	=	8 fluid drams
1 pint (pt)	=	16 fluid ounces
1 quart (qt)	=	2 pints
1 gallon (gal)	=	4 quarts

EQUIVALENTS OF METRIC AND U.S. SYSTEMS of MEASURES AND WEIGHTS

Linear

1		11	1		11
1 millimeter	=	0.03937 inch	1 inch	=	2.5400 centimeters
1 centimeter	=	0.3937 inch	1 foot	=	30.480 centimeters
1 meter	=	39.37 inches	1 foot	=	0.3048 meter
1 meter	=	3.2808 feet	1 yard	=	91.440 centimeters
1 meter	=	1.09361 yards	1 yard	=	0.9144 meter
1 kilometer	=	0.6214 mile	1 mile	=	1.6093 kilometers

To convert units of one system into the other, multiply the number of the units by the equivalent opposite that unit in column 11.

For Example:
To convert 26.5 centimeters into inches, multiply 26.5 by 0.3937--26.5 X 0.3937 = 10.433 inches. Or--to convert 8.75 inches into centimeters, multiply 8.75 by 2.54--8.75 X 2.54 = 22.225 centimeters.

SOME MULTIPLES AND SUBMULTIPLES

Inches =	Millimeters	Inches =	Centimeters
1/32	0.744	1	2.540
1/16	1.588	2	5.080
1/8	3.175	3	7.620
1/4	6.350	4	10.160
3/8	9.525	5	12.700
1/2	12.700	6	15.240
3/4	19.050	7	17.780
1	25.40	8	20.320
2	50.80	9	22.860
3	76.20	10	25.400
4	101.60	11	27.940
5	127.00	12	30.480

Millimeters =	Inches	Centimeters =	Inches
1	0.03937	1	0.3937
2	0.07874	2	0.7874
3	0.11811	3	1.1811
4	0.15748	4	1.5748
5	0.19685	5	1.9685
6	0.23622	6	2.3622
7	0.27559	7	2.7559
8	0.31496	8	3.1496
9	0.35433	9	3.5433
10	0.39370	10	3.9370

Volume

(Liquid Measure)

1	11	1	11
1 cc =	16.23 minims	1 fluid dram =	3.697 cc
1 cc =	0.2705 fluid dram	1 fluid ounce =	29.573 cc
1 cc =	0.0338 fluid ounce	1 pint =	473.167 cc
1 liter =	33.815 fluid ounces	1 quart =	946.333 cc
1 liter =	2.1134 pints	1 gallon =	3.785 liters
1 liter =	1.0567 quarts	1 cubic inch =	16.387 cc
1 liter =	0.2642 gallons		

To convert units of one system into the other, multiply the number of units by the equivalent opposite that unit in column 11. For example: To convert 4 cc into fluid drams, multiply 4 by 0.2705--4 X 0.2705 = 1.082 fluid dram. Or--to convert 6.5 fluid ounces into cc, multiply 6.5 by 29.537--6.5 X 29.537 = 192.224 cc.

Gold is weighed according to the Troy weight which is as follows:

24 grains	=	1 DWT (Pennyweight or hundred weight)
20 DWT	=	1 oz (ounce)
12 oz	=	1 lb.

CHAPTER V

TEMPERATURE

Temperature (pyrometry) is measured by four different scales.

1. Fahrenheit (F^o)
2. Centigrade (metric) (C^o)
3. Reaumur
4. Absolute

Of the four the F and C scales are the most common. The centigrade scale is based upon the freezing and boiling points of water which are 0 and 100 respectively. The scale is divided into 100 degrees according to the metric system.

In the Fahrenheit scale we find that a mixture of salt and ice were used to get a new low temperature. This temperature was called "zero temperature." Gabriel Daniel Fahrenheit retained body temperature as the high temperature which brought the boiling point of water to 212^o F.

In Reaumur's scale we find 0^o to be the freezing point of water but the boiling point is measured at 80^o.

The absolute scale is only used in scientific work and is based on the behavior of gases which loose 1/273 of their volume for each degree fall in temperature. Thus the coldest temperature would be -273^o at which point the volume of a gas would theoretically be nil. This is a fallacy because gases are turned into liquids and the gas laws are not applicable to liquids.

Two simple equations are to be remembered in connection with temperature scales.

1 - To convert F^o to C^o
$F^o - 32 \times 5/9 = C$ or
$F^o - 32 \times 5 \div 9$

2 - To convert C^o to F
$C \times 9/5 + 32 = F$ or
$C \times 9 \div 5 + 32 = F$

Melting points of important metals.

	C^o	F^o
Aluminum - Al	658	1218
Antimony - Sb	630	1167
Bismuth - Bi	271	520

Melting points of important metals (continued)

		C°	F°
Cadmium	- Cd	320	609
Copper	- Cu	1083	1981
Gold	- Au	1063	1945
Iron	- Fe	1535	2795
Lead	- Pb	327	621
Mercury	- Hg	-38.8	-38
Platinum	- Pt	1755	3191
Silver	- Ag	960	1761
Tin	- Sn	232	449
Zinc	- Zn	419	786